Landsat 7 Processing System (LPS) System Design Specification

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GODDARD SPACE FLIGHT CENTER
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Processing System (LPS)
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Abstract

The Landsat 7 Processing System (LPS) provides Landsat 7 data receive and processing support to the Landsat 7 program, in conjunction with the Earth Science Mission Operations (ESMO) Project. The LPS receives raw wideband data from the Landsat 7 Ground Station, located at the EROS Data Center (EDC), processes it into Level 0R, browse and metadata files, and provides them to the Landsat Processes Distributed Active Archive Center (LP DAAC), also located at the EDC. The system design presented in this document is based on the requirements contained in the LPS Functional and Performance Specification (F&PS) and the LPS Operations Concept document.

Keywords: Landsat 7
Landsat 7 Processing System (LPS)
Landsat 7 Ground Station (LGS)
Landsat Processes Distributed Active Archive Center (LP DAAC)
Functional and Performance Specification (F&PS)
Mission Operations and Data Systems Directorate (MO&DSD)
Systems Management Policy (SMP)

Preface

This system design specification contains the highest level design information for the LPS. The LPS system design is based on an analysis of the requirements contained in the LPS Functional and Performance Specification (F&PS), the LPS Operations Concept document, and results from various technical analysis, prototyping and trade-off studies performed by the LPS Project. This LPS system design specification, once baselined at/after the System Design/Software Requirements Review (SD/SRR) , will be controlled by the IPD (Code 560) configuration control board (CCB) and maintained and updated, as required, by the LPS Project.

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LPS System Design TBD/TBR List

The following items pertaining to LPS System Design are still to be determined (TBD) and/or to be resolved (TBR):

SDS Reference	**TBD/TBR Description**
2.4	LPS-LP DAAC interface - Specific system design details on DAN/DTA handshake, connection type and the HDF 2 GB file size restriction are still under investigation.
Appendix C.5	(same as in 2.4 above)

3. System Design

4. System Support Software

5. Operations Design

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1. Introduction

1.1 Purpose and Scope

The purpose of this document is to establish the system design for the Landsat 7 Processing System (LPS). The LPS system design is based on an analysis of the requirements contained in the LPS Functional and Performance Specification (F&PS) and the operations concept, as well as the various technical and prototype studies completed by the LPS Project.

1.2 Goals and Objectives

The LPS system design goals are the following:

a. Provide Level 0R processing in support of the Landsat 7 ground segment.

b. Minimize LPS development and operations and maintenance (O&M) costs by maximizing the use of Commercial-Off-the-Shelf (COTS) hardware and software components.

c. Provide portability and re-use of LPS software to support insertion of higher performance technologies throughout LPS development and operations.

1.3 System Description

A baselined overview of the LPS system description can be found in the LPS Operations Concept Document (Applicable Document 9).

1.4 Definitions

The following terms, as defined in this section, are commonly used throughout this document to describe the LPS operations concept.

1. Landsat 7 Contact Period: The time duration between the start and end of wideband data transmissions from the Landsat 7 spacecraft to a ground station.

2. Interval: The time duration between the start and stop of an imaging operation (observation) of the Landsat 7 ETM+ instrument.

3. Sub-Interval: A segment of raw wideband data interval received during a Landsat 7 contact period. Sub-intervals are caused by breaks in the wideband data stream due to communication dropouts and/or the inability of the spacecraft to transmit a complete observation (interval) within a single Landsat 7 contact period. The largest possible sub-interval can be as long as a full imaging interval. The smallest possible sub-interval can be as small as one full ETM+ scene with a time duration of approximately 24 seconds.

4. Level 0R Files: The reformatted, unrectified sub-interval data having a sequence of pixels which are spatially consistent with the ground coverage and appended with radiometric calibration, attitude, and ephemeris data. Figure 1-2 illustrates the relationship of LPS files to the received sub-intervals.

Level 0R Instrument Data File: Each file contains the image data from a single band in a single subinterval. The data is grouped by detectors, i.e., for a given major frame, detector 1 data is followed by detector 2 data etc. Reverse scan samples are changed to forward order. This data is nominally aligned using fixed and predetermined integer values that provide alignment for band offset, even/odd detectors, and forward and reverse scans. Quality indicators are appended for each major frame.

Calibration File: One file is created for each sub-interval. This file contains all of the calibration data received on a major frame basis for a given sub-interval. This is the data received after the Scan Line Data (which follows the End of Line Code) and before the next major frame sync, as described in Applicable Document 3. The data is grouped by detectors, i.e., for a given major frame, detector 1 data is followed by detector 2 data etc. Reverse scans are reversed. The spacecraft time of the major frame corresponding to this data is appended, as well as the status data.

Mirror Scan Correction: One file is created for each sub-interval. This file contains the Scan Line Data extracted from the two minor frames following the End of Line Code in each major frame of the sub-interval . The Scan Line Data includes the first half scan error (FHS ERR), the second half scan error (SHS ERR), and the Scan direction (SCN DIR) information. The spacecraft time of the major frame corresponding to this data is appended.

Payload Correction Data (PCD): One file created for each sub-interval. This file contains the PCD major frames received during a subinterval on a full PCD cycle basis. Quality indicators will be appended on a minor frame basis.

5. Browse Image File: A reduced data volume file of the Level 0R data which can be viewed to determine general ground area coverage and spatial relationships between ground area coverage and cloud coverage. This file contains reduced resolution scenes of the full resolution scene data contained in the Level 0R instrument data files of a sub-interval.

Monochrome Browse: Contains browse image data for a single band.

Multi-band Browse: Contains browse image data from 3 predefined bands of the ETM+ Format 1 scene data.

6. Metadata: One metadata file is created for each sub-interval. The metadata contains information on the Level 0R data provided in the sub-interval, and the names of the Level 0R instrument data, calibration data, PCD, MSCD and browse image files associated with the sub-interval. Metadata also contains quality and accounting information on the return link wideband data used in generating the Level 0R file(s). In addition, metadata includes quality and accounting information on received and processed PCD, and cloud cover assessment for the Worldwide Reference System (WRS) scene contained in the sub-interval. The metadata is used by LP DAAC users to determine the sub-interval and/or WRS scene level quality of the Level 0R data stored in the LP DAAC archive.

7. Return Link Quality and Accounting Data: The data quality and accounting information collected by LPS from CCSDS Grade 3 and Bose-Chaudhuri-Hocquenghem (BCH) error detection and correction processing of the raw wideband data received from LGS on a Landsat 7 contact period basis.

8. Level 0R Quality and Accounting Data: The data quality and accounting information collected by the LPS, on a sub-interval basis, from processing of the ETM+ major frames constructed from the wideband Virtual Channel Data Units (VCDUs) received during a Landsat 7 contact period.

1.5 Applicable Documents

The following documents contain additional details regarding the LPS, the Landsat 7 System and Project, and external systems.

1.5.1 Applicable Documents

These documents, of the exact issue dates as shown, are used for developing the LPS system design presented in this specification.

1. Consultative Committee for Space Data Systems (CCSDS), Recommendation for Space Data System Standards; Advanced Orbiting Systems (AOS), Networks and Data Links: Architectural Specification, Blue Book, CCSDS 701.0-B-1, Issue 1, October 1989

2. NASA GSFC/MO&DSD, Landsat 7 Processing System (LPS) Functional and Performance Specification, Working Draft, 560-8FPS/0194, September 1994.

3. Martin Marietta Astro Space (MMAS), Landsat 7 System Data Format Control Book (DFCB), Revision A, Volume 4 - Wideband Data, 23007702, December 2, 1994.

4. NASA GSFC, Interface Control Document (ICD) between the Landsat 7 Ground Station (LGS) and the Landsat 7 Processing System (LPS), September 1994.

5. NASA GSFC, Interface Control Document between the EOSDIS Core System (ECS) and the Landsat 7 System, Working Draft, 194-219-SE1-003, August 1994. [Note: includes LPS-LP DAAC interface requirements].

6. NASA GSFC, Memorandum of Understanding between the Landsat 7 Processing System and the Mission Operations Center (MOC), 1995.

7. NASA GSFC, Interface Control Document between the Landsat 7 Processing System and the Image Analysis System (IAS), 23007630, 1994.

8. Computer Sciences Corporation, Structured Systems Design Methodology, July 1989.

10. NASA GSFC/MO&DSD, Landsat 7 Processing System (LPS) Operations Concept, Draft, 560-3OCD/0194, September 1994.

1.5.2 Reference Documents

These documents are used as sources of additional and background information, as required, for developing the LPS system design.

1. GSFC/MO&DSD, Systems Management Policy, MDOD-8YMP/0485, July 1986.

2. National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) Landsat 7 System Specification, Review issue, 430-L-000-2-A, August 1994

3. NASA GSFC, Landsat 7 Ground Station (LGS) Functional and Performance Specification, Volume 1, Revision 1.0, November, 1994

4. NASA GSFC, Landsat 7 Ground Station (LGS) Operations Concept, 531-OCD-GS/Landsat 7, November, 1994

5. Martin Marietta Astro Space, Landsat 7 Image Assessment System (IAS) Operations Concept, Landsat 7 Library No. 5527, September, 1994

6. National Aeronautics and Space Administration (NASA) Landsat 7 Level 1 Requirements, Draft Issue, August 8, 1994.

7. United States Geological Survey (USGS)/National Oceanic and Atmospheric Administration (NOAA), Index to Landsat 7 Worldwide Reference System (WRS), 1982

8. Martin Marietta Astro Space, Landsat 7 System Program Coordinates System Standard, proposed update draft, 23007610A, August 1994.

9. NASA GSFC, LPS Software Management Plan, August 1994.

10. NASA GSFC, Landsat 7 Detailed Mission Requirements, January, 1995.

11. NASA GSFC, Landsat 7 System and Operations Concept (Pre-CCB Baseline version), 430-11-06--003-0, , October 1994.

2. System Design Overview

This section provides an overview of the LPS system design. It discusses the various design drivers, underlying assumptions, and constraints which significantly affect the system, operational, hardware, and software aspects of the LPS system design. This section also describes the LPS system design approach and includes a list of open issues having potential impact on LPS system design.

2.1 LPS Design Drivers

An LPS design driver is defined as a key system requirement which significantly affects the LPS system architecture, hardware and software design, and/or the operational approach. It is expected that changing such a requirement will have a noticeable impact on some aspects of the LPS system design. The following are the LPS design drivers.

a. The LPS must accept and record4 simultaneous data streams from the Landsat Ground Station (LGS), each with a rate of 75 Mbps. The LPS must be able to receive and record at least 3 back-to-back passes each with a maximum duration of 14 minutes. These requirements drive the hardware and software designs, which must be capable of high-rate data acquisition and storage. The LPS hardware design must include sufficient capacity. This requirement also drives the operational approach, which must manage the allocation of LPS string resources between data receipt and data processing.

b. LPS must be able to receive and process a daily volume of 250 Landsat 7 ETM+ scenes and must also be able to re-process approximately 10% of the raw wideband data received. This requirement drives the processing capacity included in the system design, which must be sufficient for both original processing and reprocessing.

c. LPS must provide the capability to retrieve stored wideband data at rates equal to or greater than 7.5 Mbps for each LPS input to allow time to process wideband data and forward it to the LP DAAC. These requirements drive the selection of storage devices. These requirements also drive the operational approach, which must include provisions for manual creation and maintenance of the data store.

d. LPS must provide continuous operational availability, must allow system maintenance and upgrade without reducing operational capabilities, and must have an availability (Ao) of at least 0.96.

These requirements drive the level of hardware redundancy included in the system level (reference) architecture.

2.2 LPS Design Assumptions

An LPS design assumption is defined as a statement with significant consequence for the design which is accepted as true but which cannot be traced to baselined project documents. The LPS design is based on the following assumptions.

a. Mission Operations Center (MOC) time correction uploads occur while the ETM+ instrument is off; there are no time jumps within an interval's data stream.

b. LPS reliability requirements allow partial data loss due to LPS string failure during a pass.

c. Landsat 7 contact schedules provide a sufficiently accurate basis for all LPS data receipt control.

d. There are no required data or control interfaces between LPS strings, including each string's communications with the Land Processes Distributed Active Archive Center (LP DAAC); each will function independently.

e. Level 0R instrument data files are produced on a band by band basis for each sub-interval.

f. The LPS processes and retains raw wideband data on-line for no more than 3 back-to-back passes and no more than 6 passes per day.

h. There is no requirement to provide data that has failed either CCSDS Grade-3 processing or BCH error detection and correction to external entities.

i. All data for a given subinterval is contiguous within a data stream; any change in Virtual Channel Identifier (VCID) in the data stream indicates the end of the current subinterval and the start of a new one.

j. The LPS will receive only data and clock signals from the LGS and will not receive control signals such as sync or lock.

k. The LGS will perform any switching of input signal lines for the purpose of failover or maintenance.

l. The LPS/Image Assessment System (IAS) and LPS/MOC interfaces are accomplished entirely by operator-to-operator voice and paper communications.

m. The LPS/LP DAAC interface is automated and electronic. There is a direct, electronic connection between the LPS and the LP DAAC over which automatic data transfer coordination occurs. LPS output files are only transferred electronically; there is no physical medium interface.

o. The LP DAAC is responsible for determining the success of LPS output file transfers.

p. Adequate security for the LPS/LP DAAC interface is provided by identification and authentication sequences at the establishment of each connection.

q. The LP DAAC notifies the LPS of the output files received for a contact period.

r. The aggregation of I and Q channels is not an LPS requirement.

s. The nominal capture duration for 3 passes is 34 minutes.

t. Processed data volume will have a 10% increase in size.

2.3 LPS Design Constraints

An LPS design constraint is defined as an external factor that limits system design options or mandates specific elements in the design. The LPS design is constrained by the following considerations.

a. The LPS system design is constrained by limited resources to produce a design that minimizes development costs, even at the expense of increased life-cycle (specifically, operational) costs.

b. LPS system requirements mandate the use of removable media for raw wideband data storage retention.

c. The LPS/LP DAAC interface hardware must be compatible with the existing Earth Resources Observing System Data Center (EDC) network configuration.

d. The LPS/LP DAAC interface hardware must be compatible with future Earth Observation Data Information System Core System (ECS) specifications.

e. The Hierarchical Data Format (HDF) specified for LPS output files strongly compels the inclusion of the HDF run-time library and utilities package from the National Center for Supercomputing Applications (NCSA) in the system design.

f. Issues of cost and maintainability require the use of COTS hardware. The use of COTS hardware limits hardware configuration options and performance capabilities.

2.4 Open Issues

The following issues with potential impact to the LPS system design are still known to be open:

a. LPS-LP DAAC interface - Specific system design details on DAN/DTA handshake and HDF 2 GB file size restriction are still under investigation.

2.5 System Design Approach and Methodology

This section provides a brief description of the methods used to specify the LPS system design. Section 2.5.1, "Approach and Methodology," describes the system design specification process. Section 2.5.2, "Structured Analysis Conventions," describes the structured analysis notation used in this document. Section 2.5.3, "Design Tools," describes the automated tools used in the system design process.

2.5.1 Approach and Methodology

The LPS system design has been developed using the Structured System Design Methodology (described in Applicable Document 8) tailored to suit the LPS project environment. The LPS system design has been accomplished by performing the following major activities:

a. Analysis of LPS system requirements and operations concept to identify system design drivers, constraints and assumptions.

b. Functional decomposition of LPS system requirements via structured analysis to define the scope of the LPS system, its subsystems, and their interfaces.

c. Analysis of LPS system requirements and operations concept to determine the allocation of LPS requirements to LPS system, hardware, software, and operations.

d. Development and analysis of LPS system architecture alternatives and the selection of an LPS architecture that meets system requirements, is based on well defined assumptions and constraints, proves itself feasible through prototyping studies, and meets or surpasses a set of predefined evaluation criteria.

e. Development and analysis of LPS hardware configuration alternatives and the selection of one that is adequately sized to meet or exceed the LPS workload and performance requirements stated in the F&PS.

f. Development and analysis of an LPS software architecture that is based on LPS structured analysis, conforms to the selected hardware configuration and constraints, and maximizes the use of COTS items in its design.

g. Performance of technical analysis and trade studies to support the LPS system design decision making process, including the following studies.

   - LPS workload and traffic analysis
   - Data storage and communication studies
   - Compute processor selection trade-off studies
   - Reliability, Maintainability and Availability (RMA) analysis
   - Operational timeline analysis
   - System and operational cost analysis
   - Software sizing analysis
   - System/Implementation risk analysis
   - COTS [such as Oracle Database Management System (DBMS) and NCSA Hierarchical Data Format (HDF)] evaluation/analysis

h. Generation of the LPS system design specification.

i. Generation of the LPS preliminary Interface Data Descriptions (IDDs).

j. Identification of LPS issues which, when resolved, may impact the LPS system design.

The following sections provide brief discussions on LPS system architecture, hardware, and software selection approaches.

2.5.1.1 System Architecture Selection

The LPS system architecture was developed by the following method.

- Define a set of alternative system architectures likely to satisfy LPS system requirements.
- Define a set of evaluation criteria by which the alternatives can be judged.
- Evaluate each alternative according to the criteria.
- Select the highest scoring alternative as the LPS system architecture.

The architectures were evaluated using the criteria described in Table 2-1. The set of alternative system architectures and details of their evaluation can be found in Appendix B.1.

Table 2-1: LPS Architecture Evaluation Criteria

Criteria	Rationale
Cost	The LPS project is constrained to minimize development costs.
Automation	Higher automation reduces life-cycle costs, but increase development costs. Only limited automation is possible
System RMA	LPS must provide an Ao of 0.96 or better. If a failure occurs, the LPS should be able to receive the next contact.
Ease of Upgrade	Landsat 7 data processing at a real-time rate is now prohibitively expensive. The architecture should allow easy, modular upgrade to higher performance items.
Software Portability	LPS software should transport easily to upgraded system hardware.
Maintainability	The LPS will be delivered to EDC, a non-NASA site. The selected architecture components and/or subsystems should be easily maintainable by EDC.
Standards Compliance	LPS will provide Level 0R data to the LP DAAC for distribution to the ECS user community. This requires that the LPS should comply with commercial, NASA, and ECS standards for transferring data to external systems.

2.5.2.2 Hardware Configuration Selection

The LPS system architecture was developed by the following method.

- Define a set of alternative hardware configurations likely to satisfy LPS system requirements.
- Define a set of evaluation criteria by which the alternatives can be judged.
- Prototype alternative hardware configurations to verify that they will satisfy LPS requirements.
- Evaluate each alternative according to the criteria.
- Select the highest scoring alternative as the LPS hardware configuration.

The hardware configurations were evaluated using the criteria described in Table 2-2. The hardware architecture alternatives primarily involve changes to the front end to implement the realtime data capture and retrieval. These alternatives are described in Appendix B.1.

Table 2-2: LPS Hardware Configuration Evaluation Criteria

Criteria	Rationale
Performance	The LPS must receive and record wideband data at 75 Megabits Per Second (Mbps) per LGS channel, must provide sufficient storage to retain recorded wideband data on removable media, and must support processing throughput of 7.5 Mbps per LGS channel.
COTS Content	Reduce labor costs associated with custom hardware development.
Software Flexibility	Minimize the constraints placed on software implementation.

2.5.2.3 Software Architecture Selection

The LPS software architecture was developed by the following method.

- Decompose LPS functional requirements via structured analysis to produce more detailed requirements.
- Define subsystems by grouping detailed requirements.

- Evaluate the resulting architecture based on criteria described in Table 2-3 with emphasis on the functional cohesion of subsystems and the coupling between them.
- Re-partition the subsystems and re-evaluate until the resulting architecture satisfies the evaluation criteria.

Table 2-3: Software Evaluation Criteria

Criteria	Rationale
Coupling	Coupling measures the strength of association between LPS software subsystems. The LPS software should be designed in such a way that subsystems are loosely coupled and modification of one subsystem will not strongly impact other subsystems.
Cohesion	Cohesion measures the strength of association of elements within a LPS software subsystems. The LPS software should be designed in such a way that each subsystem represents a functionally cohesive segment of the LPS software system.
Re-use	The LPS software architecture should maximize potential software re-use.

2.5.2 Structured Analysis Conventions

Structured analysis for LPS system design uses Yourdon and Constantine structured analysis notation conventions, illustrated in Figure 2-1. Products of structured analysis for LPS system design consist of the top-level or Level 0 data flow diagrams (DFDs) and context diagrams. A DFD is a logical, graphical representation of data transformations performed by system or subsystem on its inputs to produce its outputs. A context diagram is a special top-level DFD that names the system and subsystems to be designed and that defines the bounds of a system or subsystem in terms of the data it receives and generates.

2.5.2.1 Data Dictionary

The Data Dictionary (DD) is the single LPS repository for each unique data flow, data store, and any acronyms or other items that are defined in the data flow diagrams but are not part of a typical user's vocabulary. Each Data Dictionary Entry (DDE) must contain the name of the item, all aliases by which the item is known, a definition, and any notes or comments to further explain the item. If the defined item contains other items, the defining items must be listed in addition to the description. The name of the DDE must conform to the LPS naming convention.

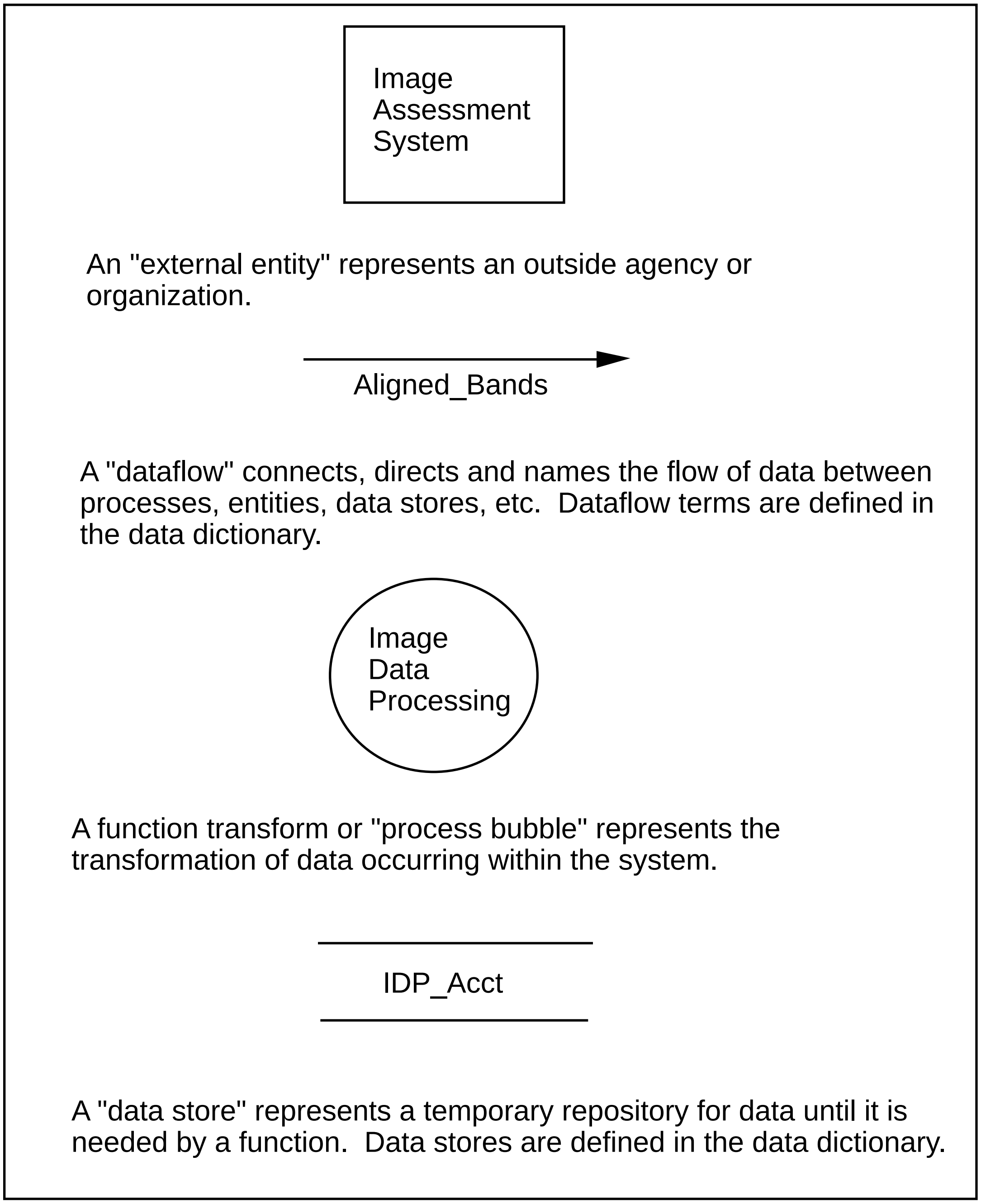


Figure 2-1: LPS Structured Analysis Conventions

2.5.3 Design Tools

CADRE Teamwork is the structured analysis tool used by the LPS system designers. Teamwork supports the Yourdon and Constantine method of structured analysis. System designers used Teamwork to create the LPS data dictionary, context diagrams, and data flow diagrams. Teamwork provides checking features that allowed the designers to verify the completeness and accuracy of the generated diagrams.

The Marconi Requirements and Traceability Management (RTM) tool is used to map the LPS system requirements to the subsystem that will address them. RTM interfaces with a COTS database to track and manage the system requirements. RTM also interfaces with Teamwork by allowing the software developer to create links between the graphical representations of each subsystem, created by Teamwork, and the requirements that are satisfied by each. RTM assists the software developers in ensuring that each requirement is being addressed during the system design phase, satisfied during the implementation phase, and verifiable during the test phase of the software life cycle.

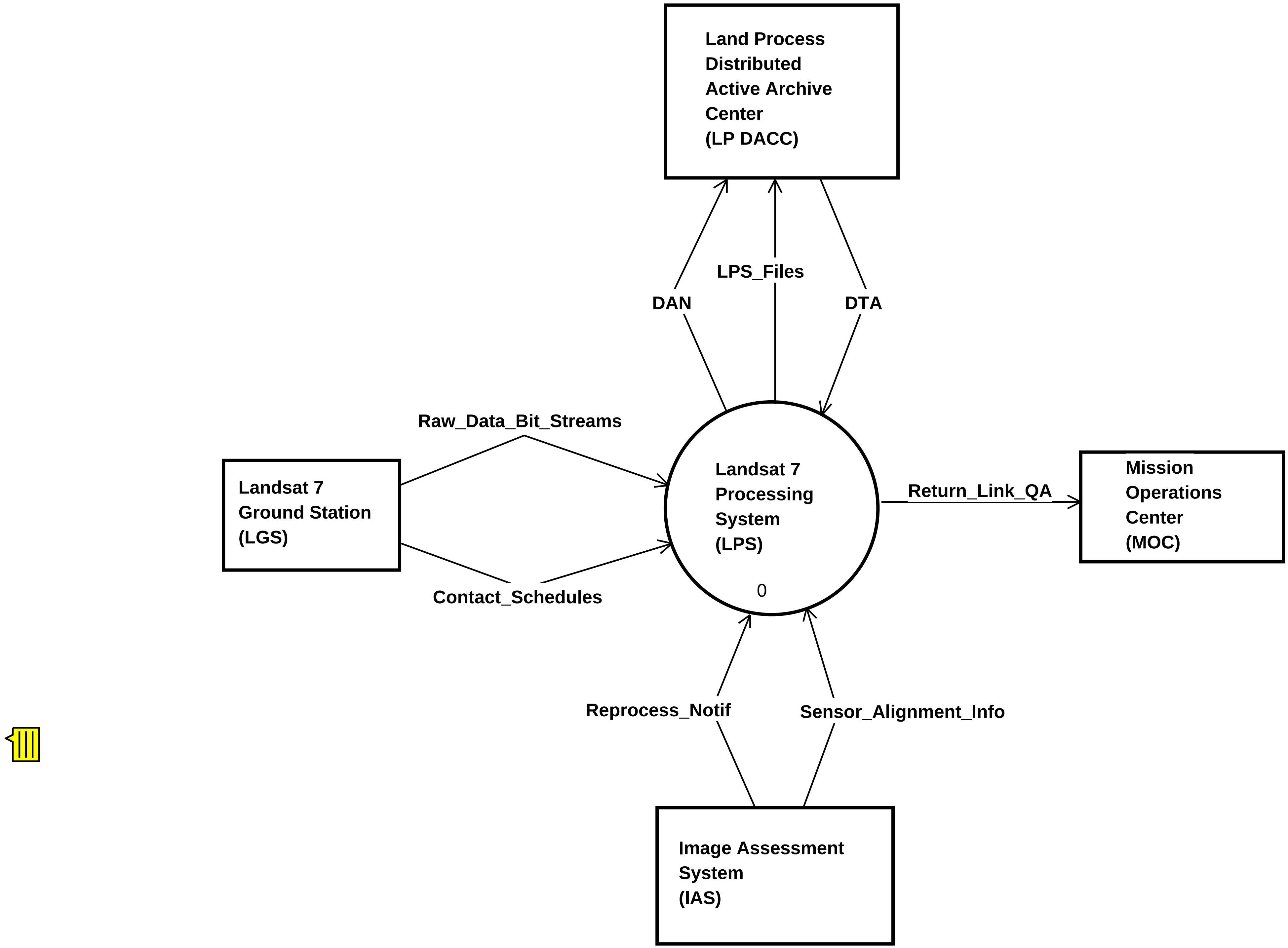
2.6 LPS System Architecture

This section describes the LPS system architecture. Where appropriate, references to summary results from system design studies are provided. Detailed results from LPS system design activities, analysis and trade-studies are provided in Appendix B.

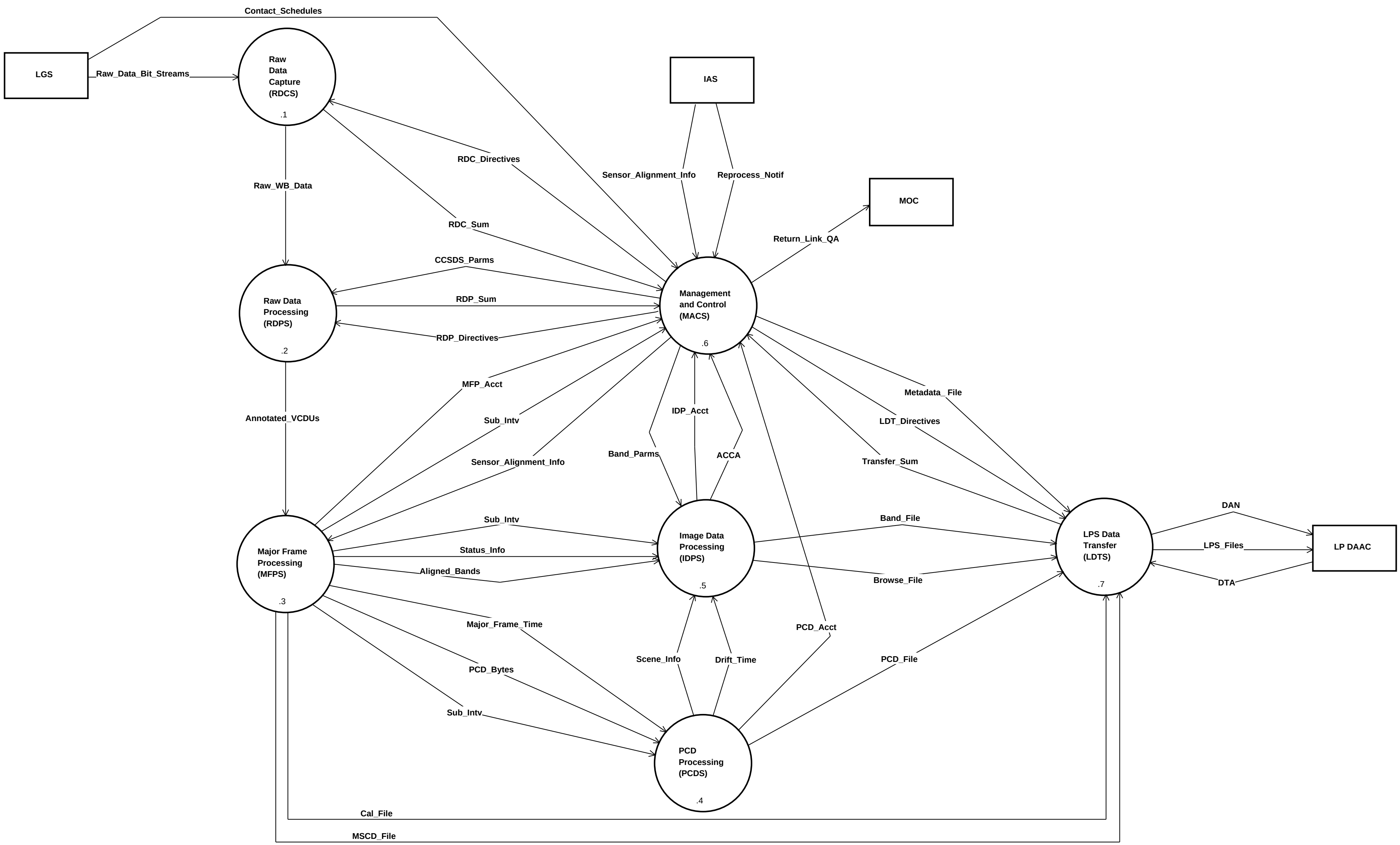
The LPS system design consists of a reference architecture (system concept) for the LPS, the hardware and software configuration items that support that architecture, and operations considerations based on the system architecture.

The LPS reference architecture is based on a structural analysis of LPS functional characteristics and data flows. It consists of two major components: the LPS functional flow architecture and the LPS interconnect architecture. The LPS functional flow architecture consists of a set of data flow diagrams (DFDs) including the LPS context diagram and the level 0 diagram. These diagrams are shown in Figures 2-2 and 2-3, respectively. The LPS context diagram focuses on LPS external data flows while the Level 0 diagram provides a breakdown of the LPS into its subsystems and identifies inter-subsystem data flows. The LPS interconnect architecture provides a system block level (hardware) interconnect view of the LPS showing allocation of LPS subsystems to system blocks to convey the LPS implementation concept. Figures 2-4 and 2-5 show the LPS interconnect architecture.

Context-Diagram;11
Landsat 7 Processing System



1;20
Top_Level_DFD



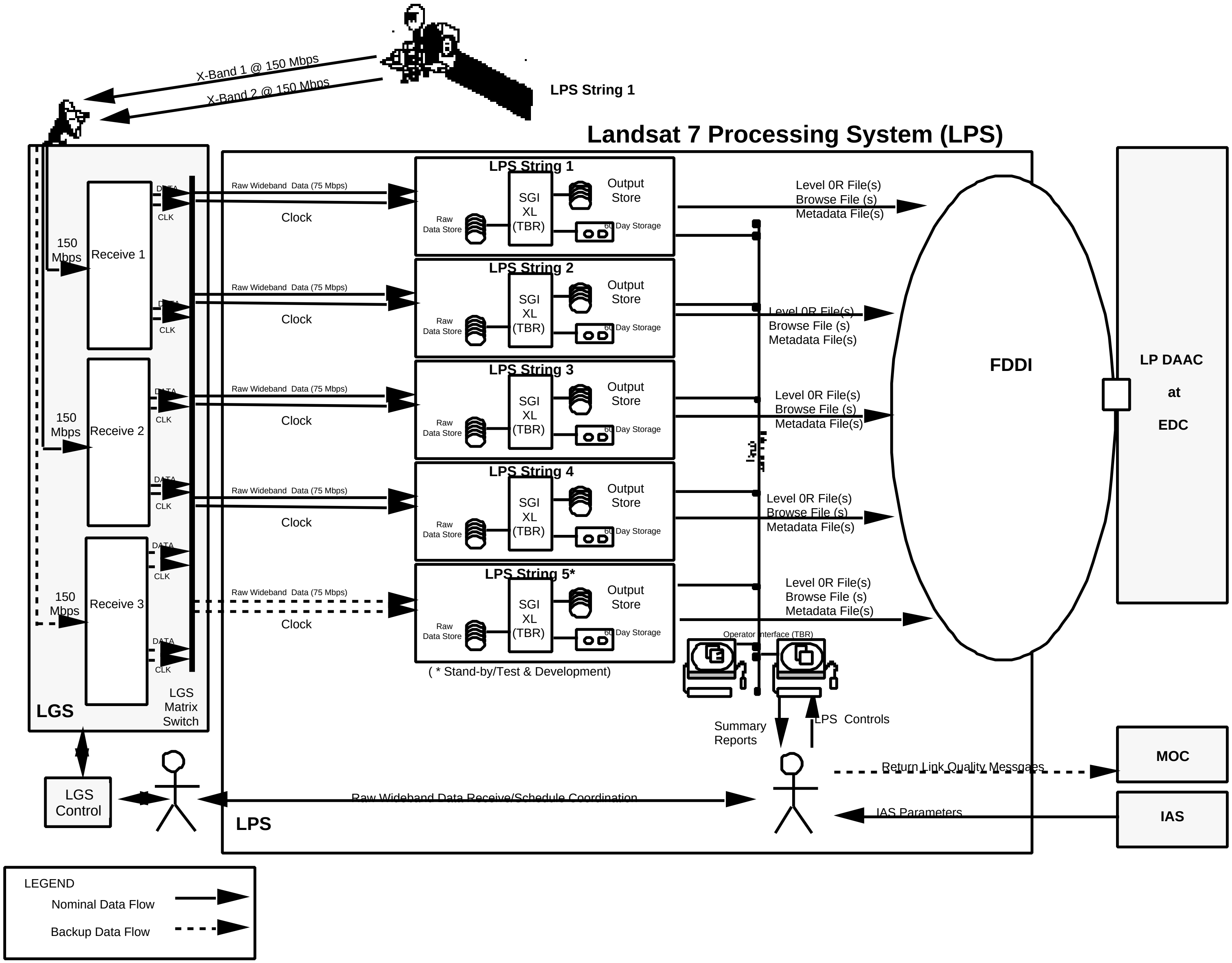


Figure 2-4: LPS Interconnect Architecture

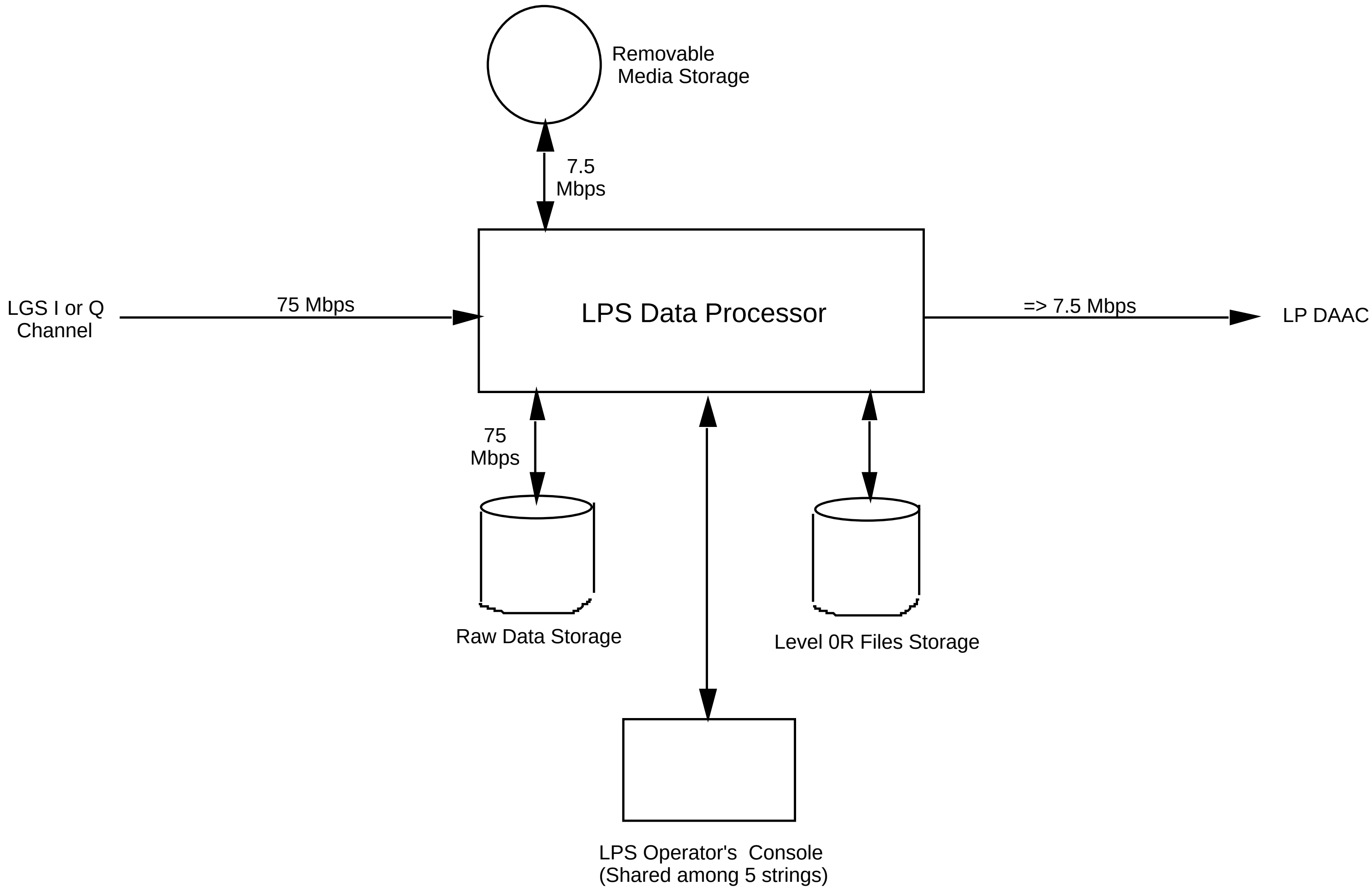


Figure 2-5: LPS String Block Diagram

2.6.1 LPS Functional Flow Architecture

The LPS Level 0 diagram is based on an analysis and allocation of the LPS system requirements, contained in Applicable Document 9, and their synthesis to define the LPS subsystems and interfaces. The LPS consists of the following subsystems.

a. Raw Data Capture Subsystem (RDCS)

b. Raw Data Processing Subsystem (RDPS)

c. Major Frame Processing Subsystem (MFPS)

d. PCD Processing Subsystem (PCDS)

e. Image Data Processing Subsystem (IDPS)

f. Management and Control Subsystem (MACS)

g. LPS Data Transfer Subsystem (LDTS)

The LPS functional flow architecture serves as the main driver for the LPS software architecture. Specific details on the LPS subsystems shown in this architecture are provided in Section 3.

2.6.2 LPS Interconnect Architecture

The LPS interconnect or system block diagram is based on the results of the LPS architecture trades and workload analysis studies discussed in Appendix B.1 and Appendix B.7, respectively.

The LPS consists of 5 logically independent processing strings as shown in Figure 2-4. The LPS operations uses 4 processing strings at all times to support normal operations. The fifth string is available for LPS test and maintenance support, as required, and as a back-up string for the 4 operational strings. Each LPS string consists of the following system blocks as shown in Figure 2-5:

a. Raw data storage

b. Removable media storage

c. LPS data processor

d. Level 0R files storage

e. LPS operator's console

The LPS interconnect architecture as shown in the LPS system block diagram serves as the main driver for the LPS hardware configuration. Specific details on the LPS system blocks are provided in section 2.7.

2.7 LPS Hardware Design

This section specifies the LPS hardware design. Section 2.7.1, "Hardware Configuration Items," lists and describes each Hardware Configuration Item (HWCI) and Hardware Component (HWC). Section 2.7.2, "Hardware Performance Analysis," explains how the hardware design satisfies LPS performance requirements.

2.7.1 Hardware Configuration Items

The block level hardware configuration for a single LPS string is shown in Figure 2-6. The configuration is reproduced identically for each of the 5 LPS strings. Each string receives raw wideband serial data and clock from the LGS. LPS processes the data to Level 0R and transfers it to LP DAAC via the Fiber Distributed Data Interface (FDDI) Local Area Network. The raw wideband data from LGS is also stored on Digital Linear Tape (DLT). It should be noted that feasibility prototyping for capturing raw wideband data direct to disk and for DLT tape storage will continue during the next development phase.

The LPS hardware consists of 5 independent strings. Each LPS hardware string consists of the following HWCIs and constituent HWCs**.**

2.7.1.1 Raw Data Capture HWCI

This HWCI consists of the following HWC:

a. 32 Gigabyte (GByte) Redundant Array of Inexpensive Devices (RAID) Array.

The 32 GByte disk array is connected to the Silicon Graphics, Incorporated (SGI) Challenge via a Small Computer Systems Interface (SCSI-2 fast/wide) controller. The disk array capacity is sized to store and buffer raw wideband data from a maximum of 3 contact periods each with a total time duration of 35.15 minutes.

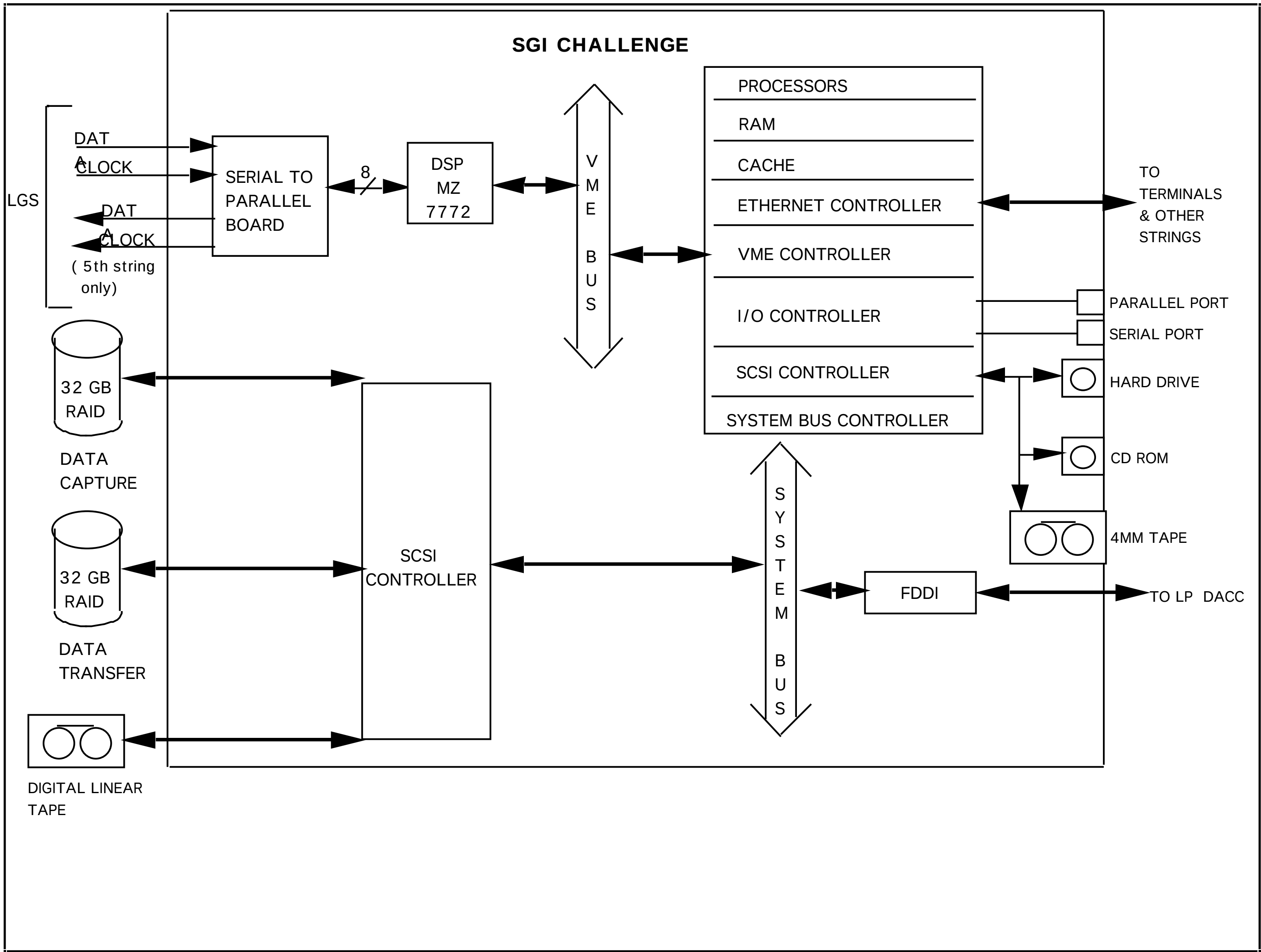


Figure 2-6: LPS Block Level Hardware Configuration

2.7.1.2 Data Process HWCI

This HWCI consists of the following HWCs:

a. SGI model Challenge XL Computer.

The SGI Challenge servers are multi-processor systems designed for distributed computing environments. Their parallel architecture is based on a 1.2 GByte per second system bus and can support up to 16 GBytes of RAM. Among the items included with the standard subsystem are an Ethernet controller, Versa Module European (VME/64) controller, SCSI controller, parallel and serial ports.

LPS requires a multi-processor solution to satisfy its computational requirements, which are beyond the current capacity of a single processor. A set of distributed multi-processors allows multiple applications concurrent access and eases contention. There is less impact due to single failures.

b. Serial-to-parallel Board.

A custom serial-to-parallel board is installed in the SGI VME backplane. It converts the serial data to 8 bit bytes for parallel transfer to the Digit Signal Processing (DSP) board.

The serial-to-parallel board can also receive data from the DSP board and transmit it to LGS for test purposes. A data pattern generator is incorporated in the serial-to-parallel board to allow for testing.

c. MIZAR MZ 7772 DSP Board.

The MIZAR Inc. MZ 7772 DSP circuit board consists of four Texas Instruments TMS 320C40 digital signal processors. It is installed in the SGI VME chassis. Data from the serial-to-parallel board is received by a DSP communication port and transferred to the SGI via the VME bus interface on the DSP board.

d. FDDI LAN Controller Board.

The FDDI LAN connects each LPS string to LP DAAC. The LPS to LP DAAC interface is currently under study.

e. SCSI/2 Controller Board.

This controller provides the additional ports for the external disk arrays and tape drive.

2.7.1.3 Data Transfer Store HWCI

This HWCI consists of the following HWC:

a. 32 GByte RAID Array.

The 32 GByte disk array is connected to the SGI Challenge via a SCSI-2 controller. The disk array capacity is sized for storing the level 0R processed LPS data files from three contact periods for a maximum duration of 8 hours.

2.7.1.4 60-day Data Storage HWCI

This HWCI consists of the following HWC:

a. DLT Drive.

A DLT drive is connected to the SGI Challenge via a SCSI/2 controller board. The tape drive has a bandwidth of 20 Mbps and a total storage capacity of 10 GBytes of data (10 GBytes per cartridge, uncompressed).

2.7.1.5 Operations Interface HWCI

This HWCI consists of the following HWC:

a. Two Indy workstations.

Two workstations are connected to the Ethernet LAN and to each Challenge CPU via a serial cable. The operation of all five LPS strings is controlled by these workstations. Additionally, these workstations will perform non-mission support duties such as help and printing.

2.7.2 Hardware Performance Analysis

A description of the proposed architecture and associated block diagram are contained in section 2.7.1. and Figures 2.4 and 2.6. This architecture will be used as the basis for the following analysis.

The analysis focuses on the processing throughput and transfer rates to determine how they fulfill the requirements of realtime data capture at 75 Mbps and post processing at 7.5 Mbps. Discussion of the required storage capacities is also included.

The serial-to-parallel board is designed to receive serial data at clock rates up to 80 Mbps. The rate of parallel transfer to the DSP board communication port from the serial-to-parallel board is one eighth of the serial rate since the transfer is byte wide. The DSP board communication port is rated for a maximum throughput 160 Mbps.

Data received by the DSP board communication port is stored in DSP global on-board Random Access Memory (RAM) prior to transfer across the VME bus. The DSP performs global bus transfers across the VME bus to support the incoming data rate. The received data is then moved into SGI system RAM. From SGI system RAM, where the data is memory mapped to a file, it is transferred to the Data Capture disk array. The SCSI/2 transfer rate to the disk is 20 MBytes per second. Since data is simultaneously being written and read from SGI system RAM, the system will need the bandwidth to support this data flow. The system bus transfer rate is 1.2 GBytes per second.

The Data Capture disk array has sufficient storage capacity to capture satellite contacts (16 minutes max./contact at 75 Mbps) and to facilitate the data processing.

Once the capture of the raw satellite data is completed, data processing is initiated. The data processing rate will be at a minimum average rate of 7.5 Mbps to maintain processing throughput. For a nominal capture duration of 34 minutes for 3 passes, error free processing can be completed under 6 hours.

Concurrent with data processing, the data that had been captured to disk array will be transferred to a DLT drive for 60 day storage. The DLT has a maximum transfer rate of 20 Mbps (uncompressed) and can store 10 GBytes of data per cartridge.

During Level 0R processing, output files are created on the Data Transfer Storage disk array for temporary storage prior to transferring it to the LP DACC. The processed data volume will have an approximate 10 % increase in size. Consequently, the Data Transfer Storage RAID array has a storage capacity to accommodate this data volume.

While Level 0R processing is underway, the SGI bus will be supporting the major tasks listed below. Listed along with these tasks are the associated throughput or transfer rates. This will provide an estimate of the bus loading:

1. Data transfer from Data Capture RAID (nominal)	7.5 Mbps
2. Data store to DLT (maximum)	20 Mbps
3. Data transfer to Transfer Storage RAID (nominal)	7.5 Mbps
4. Data processing (see Appendix C.7)	100 Mbps
5. Data transfer to LP DAAC (maximum)	10 Mbps
Total	210 Mbps

Data will be transferred from the Data Transfer Storage RAID to LP DAAC via a LAN at nominal throughput of 40 Mbps aggregate rate for the 4 strings (10 Mbps per string). The LPS to LP DAAC interface is currently under study.

2.8 Software Configuration Items

The LPS software architecture is outlined in this section. The system support software is discussed in the following subsection. The application software including the LPS software development considerations and the LPS subsystems is presented in the second subsection.

The main considerations for the LPS software architecture design are these goals, objectives, and requirements:

- Minimize LPS software development and life-cycle cost.
- Consider portability and re-use of LPS software to foster future technology infusion.
- Consider extensive use of COTS products to implement the LPS software.
- Fulfill LPS functional requirements in general and performance requirements in particular.

2.8.1 LPS System Support Software

The LPS system software consists of COTS software components that either satisfy LPS requirements directly or support LPS application software. LPS system support software consists of system software Software Configuration Items (SWCIs) and COTS application SWCIs. LPS system software SWCIs are as follows.

- IRIX operating system.
- Mizar MZ7772 DSP Board Support Software.
- FDDI Device Interface.
- RAID Array Device Interface.

COTS application SWCIs are as follows.

- Oracle Database Management System (DBMS).

- NCSA HDF.

Details descriptions of LPS system support software appear in section 4.

2.8.2 LPS Application Software

This section describes the application software architecture design considerations and presents a brief functional overview of LPS subsystems.

2.8.2.1 Application Software Architecture Design Considerations

The major LPS application software development considerations are described in the following paragraphs.

- **Database Management and Interface**

  To minimize the development cost and to enhance the maintainability of the LPS application, a relational DBMS is adopted as a vehicle to store LPS system status and accounting information, image data quality and accounting information, and metadata information. An interactive Structured Query Language (SQL) and SQL forms are used to manage and manipulate the information. In addition, the LPS application uses database tables for communication among subsystems to reduce the coupling of LPS subsystems. This enhances the independence and concurrence of operations within the LPS and minimizes the total effects of a failure in one subsystem.

- **User Interface**

  To simplify the user interface application, the LPS presents the users with a simple and well-defined menu structure for controlling its operations. The User Interface (UI) is based on X/Motif and Oracle's SQL*Forms. X/Motif has achieved wide acceptance and is in use at the EDC site. It provides the basis for a consistent look and feel across multiple EDC systems. The UI provides a framework within which a menu system is built. The UI is decoupled from the LPS applications themselves. It functions as a stand alone component, receiving input from the users and passing this input to the applications, enabling the display area for output from the applications to be managed.

- **POSIX Standards**

  To facilitate better portability, to ease operating system upgrade problems in the future, and to foster future technology infusion, POSIX standards are adopted for the LPS application software development. POSIX.1 is used to support the system service interface for basic operations such as process creation and termination, file and directory access, simple I/O, and extensions to the standard C library. POSIX.2 is used to support programmable shell and portable program development and user environment. Other POSIX standards, if required for software development, will be used once they become available on the SGI system. If performance requirements demand deviation from these standards, the deviating units will be isolated and clearly identified.

- **Parallel Programming**

To achieve the LPS performance requirements and to take advantage of multiprocessors provided by SGI, code which normally runs in serial mode is optimized to spread the same work over several processes running on four different Central Processing Units (CPUs) within the SGI machine. SGI supports parallel programming and provides a high level language known as IRIS Power C. The IRIS Power C directives offer a rich parallel processing environment which allows the programmer to set up the use of the multi-processor computer without sacrificing code readability, with small impact to code portability. Opportunities for applying parallel programming to LPS will be investigated and guidelines for developing parallel programs will be developed and followed.

- **Software Re-use**

To minimize the application development schedule and cost, it is desired to reuse as much existing software as possible. Identifying areas of re-use will occur throughout the LPS development life cycle. Potential reuse opportunities include reuse of existing Pacor II and DDF software for LPS to LP DAAC communications and output file management, reuse of prototypes developed in the LPS project in the areas of BCH, major frame synchronization, band deinterleaving, automatic cloud cover assessment, and browse generation, and reuse of designs and algorithms for Worldwide Reference System (WRS) scene identification and sun information calculations. Additional discussion of software re-use for the LPS appears in Appendix B.11.

- **Development Environment**

The development environment includes an ANSI-compliant C compiler, a debugger, and a Power C Analyzer (PCA) from SGI. The PCA is used to analyze the opportunities for parallel programming. In addition, Tools (Purify or others) are used to validate source code and to track down memory leak problems. The LPS software configuration management is done through the Source Code Control System (SCCS), UNIX tool, or ClearCase, a configuration management tool provided by SGI.

2.8.2.2 Application Software Subsystems

The LPS application software configuration items correspond to the subsystems defined in section 2.6, Figure 2-3. The following paragraphs describe the purpose and basic functionality of each subsystem. A detailed description of each subsystem is presented in section 3.

- **Raw Data Capture Subsystem (RDCS)**

The purpose of the RDCS is to capture and manage raw wideband data received from the LGS. This subsystem manages on-line staging storage and the 60 day data store. It moves data between the staging data store and the 60 day store to ensure sufficient disk space for data capture, to allow Level 0R processing of newly captured contact periods, and to service reprocessing requests from the user. The RDCS also collects and generates data capture accounting and subsystem status information.

- **Raw Data Processing Subsystem (RDPS)**

The purpose of RDPS is to input the rate buffered wideband data from the data store and performs CCSDS Advanced Orbiting Systems (AOS) Grade-3 service on the received Channel Access Data Units (CADUs). This subsystem supports frame synchronization and Pseudo-Random Noise (PN) decoding of the received CADUs, Cyclic Redundancy Check (CRC) on VCDUs, and Reed-Solomon (R-S) error detection and correction of VCDU headers. It also supports the BCH error detection and correction processing. The RDPS collects and generates raw data processing accounting and subsystem status information.

- **Major Frame Processing Subsystem (MFPS)**

The purpose of the MFPS is to process VCDUs. This subsystem provides the functionality to synchronize the major frames, extract major frame times, deinterleave band data, reverse band data if necessary, and align band data. It is also responsible for generating the Calibration and Mirror Scan Correction files. In addition, it determines sub-interval boundaries and extracts and provides PCD bytes for subsequent processing. The MFPS also collects and generates Level 0R accounting and subsystem status information.

- **PCD Processing Subsystem (PCDS)**

The purpose of PCDS is to process Payload Correction Data (PCD). This subsystem is responsible for performing PCD byte majority voting, PCD major frame building, and PCD file generation. In addition, it generates the WRS scene information and extracts ETM+ calibration door events. The PCDS also collects and generates PCD accounting and subsystem status information.

- **Image Data Processing Subsystem (IDPS)**

The purpose of IDPS is to perform general LPS image data processing. This subsystem generates level 0R instrument data files and browse files. It is also responsible for determining cloud coverage on a scene quadrant and full scene basis and calculating sun elevation and azimuth angles. The IDPS also collects and generates IDPS accounting and subsystem status information.

- **Management and Control Subsystem (MACS)**

The purpose of MACS is to provide an interface through which operations personnel can control the system operations, monitor overall system performance, access system accounting information, and manage the parameters used to drive system processing. This subsystem also provides capabilities to generate metadata file and accounting information.

- **LPS Data Transfer Subsystem (LDTS)**

The purpose of LDTS is to coordinate the transfer of LPS files to the LP DAAC over supported network connections. This subsystem is responsible for handling the network connections through appropriate interface and communication protocols. The LDTS is also responsible for overseeing the LPS file transmission, maintaining the status of all LPS files, managing the LPS output data store, and generating a file transfer summary.

2.9 LPS Test Support Items

The LPS system design provides an end-to-end string test capability to verify its functional, output and performance capabilities before using it in the Landsat 7 operations. Two kinds of data sets are used by the LPS to support the end-to-end string test. The LPS simulates a 75 Mbps data bit stream to support testing of the raw data capture and raw data processing functions. A canned test data set, initially acquired form the ETM+ instrument during pre-launch tests and/or generated during LPS integration, is used to test major frame processing, PCD processing, image data processing and the LPS data transfer functions. After the Landsat 7 launch, the canned test data set can be refreshed with live data from a selected contact period, when desired by the LPS operations. The LPS performs simple comparison of each test results (file outputs) with previously certified test results to verify successful completion of an end-to-end string test.

3. System Design

This section provides a detailed description of the LPS subsystems. For each subsystem, the allocated requirements, interfaces, functional description, major data items, hardware and software are described. The design presented here specifies the architecture of a single LPS string. An instance of each subsystem executes on each LPS string.

3.1 Raw Data Capture Subsystem (RDCS)

The RDCS accepts and manages raw wide band data received from the LGS. Each LGS channel's data stream for a contact period is captured to disk on a separate LPS string. The data set is subsequently copied to removable media. Upon request from the MACS, the RDCS retrieves a raw wide band data set from removable media and returns it to on-line storage for reprocessing. Upon request from the MACS, the RDCS generates a data receive summary for a specified raw wideband data set.

3.1.1 Requirements Allocation

Table 3-1 provides the RDCS requirements map. The complete mapping of LPS system requirements to subsystems is provided in Appendix A.

3.1.2 Interfaces

Figure 3-1 illustrates the RDCS's system context and external interfaces. Each instance of the RDCS on a separate LPS string receives raw wideband data for a single LGS channel from the LGS. The RDCS receives directives (RDC_Directives) to start/stop data capture, to restage a raw wideband data set, or to output a data receive summary from the MACS.

The RDCS outputs raw wide band data (Raw_WB_Data) to the Raw Data Processing Subsystem (RDPS). The RDCS outputs summary information (RDC_Sum) consisting of restage status messages and requested data receive summaries (RDC_Sum) to the MACS.

Table 3-1: RDCS Requirements Map (1 of 3)

Number	Requirements Description
3.1.1	LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.
3.1.2	LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.
3.1.3	LPS shall provide the capability to receive, process and deliver LPS output files for 4 wideband data inputs simultaneously from the LGS...
3.1.4	LPS shall process wide band data inputs from LGS on a Landsat 7 contact period (return link wide band data recording session) basis.
3.1.6	LPS shall generate Landsat 7 return link quality and accounting data on a Landsat 7 contact period basis for each wideband data input.
3.1.8	LPS shall provide the capability to reprocess wideband data.
3.1.10	The LPS shall provide an interactive intervention capability to detect and correct abnormal system conditions during LPS data capture and processing activities.
3.1.10.6	LPS shall provide the capability to test LPS functions and external interfaces.
3.1.10.7	LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.
3.1.10.8	LPS shall provide the capability to support end-to-end testing of LPS functions.
3.1.11	LPS shall provide the capability to control LPS operations.
3.1.12	LPS shall provide the capability to monitor LPS operations.
3.1.18	(requirement renumber to 3.1.10.7)
3.1.19	LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.
3.1.20	LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.
3.1.21	LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.
3.1.22	LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.
3.1.23	LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.
3.2.1	LPS shall interface with the LGS to receive wideband data ...
3.3.1.1	LPS shall provide the capability to receive return link wideband data inputs from LGS on a Landsat 7 contact period basis.

Table 3-1: RDCS Requirements Map (2 of 3)

Number	Requirements Description
3.3.1.2	LPS shall provide the capability to receive return link wide band data inputs from LGS on an LGS output channel basis.
3.3.1.3	LPS shall store return link wide band data on a Landsat 7 contact period basis.
3.3.1.4	LPS shall store return link wide band data on an LGS output channel basis.
3.3.1.5	LPS shall provide the capability to retrieve stored return link wideband data on a Landsat 7 contact period basis.
3.3.1.6	LPS shall provide the capability retrieve retained return link data on an LGS output channel basis.
3.3.1.7	LPS shall provide the capability to record return link wideband data to removable storage media, on a Landsat 7 contact period basis.
3.3.1.8	LPS shall provide the capability to save removable storage media recorded with return link wideband data.
3.3.1.9	LPS shall provide the capability to retrieve return link wideband data from removable storage media.
3.3.1.10	LPS shall generate an LPS wideband data receive summary for each Landsat 7 contact period ...
3.3.1.11	LPS shall coordinate the receipt of return link wideband data with LGS.
3.3.1.12	LPS shall maintain return link wideband data receipt capability during contact period anomalies.
3.3.1.13	LPS shall coordinate resolution of all data transfer problems with LGS.
3.3.2.13	LPS shall provide the capability to collect and store Landsat 7 return link (input) quality and accounting data...
3.3.6.1	LPS shall provide the capability to generate and modify LPS set-up tables from operator inputs.
3.3.6.2	LPS shall provide the capability to collect and report Landsat 7 return link quality and accounting data for each wideband data input on a Landsat 7 contact period basis.
3.3.6.8	LPS shall provide the capability to manually override the LPS automated functions.
3.3.6.9	LPS shall provide the capability to selectively enable and/or disable each of the following functions: a. Receive Wideband Data …
4.1.3	LPS shall provide the capability to receive and process the equivalent of 250 Landsat 7 ETM+ scenes of wideband data per day (approximately 100 GB per day).
4.1.4	LPS shall provide the capability to receive and process the daily volume of wideband data within 16 hours of its receipt at LPS.

Table 3-1: RDCS Requirements Map (3 of 3)

Number	Requirements Description
4.1.5	LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data ...
4.1.8	LPS shall introduce no more than one bit error in 10^9 bits.
4.1.9	LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a BER of one bit error in 10^5 bits, without loss of level zero processed data and without retransmission.
4.2.1	LGS-LPS interface shall provide the capability of transferring wideband data at a maximum rate of 75 Mbps per LPS wideband data input.
4.3.1	LPS shall provide the capability to receive wideband data for Landsat 7 contact periods of up to 14 minutes.
4.3.2	LPS shall provide the capability to store wideband data for at least three contact periods for each LGS input until the start of a new (the fourth) contact period.
4.3.6	LPS shall provide the capability to retain return link wideband data storage media for 60 days.
4.4.1	LPS shall provide an Operational Availability (A_o) of 0.96 or better for all processing functions.
4.4.2	LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.
4.4.3	Any LPS time to restore shall not exceed twice the required MTTRes in 99 percent of failure occurrences.

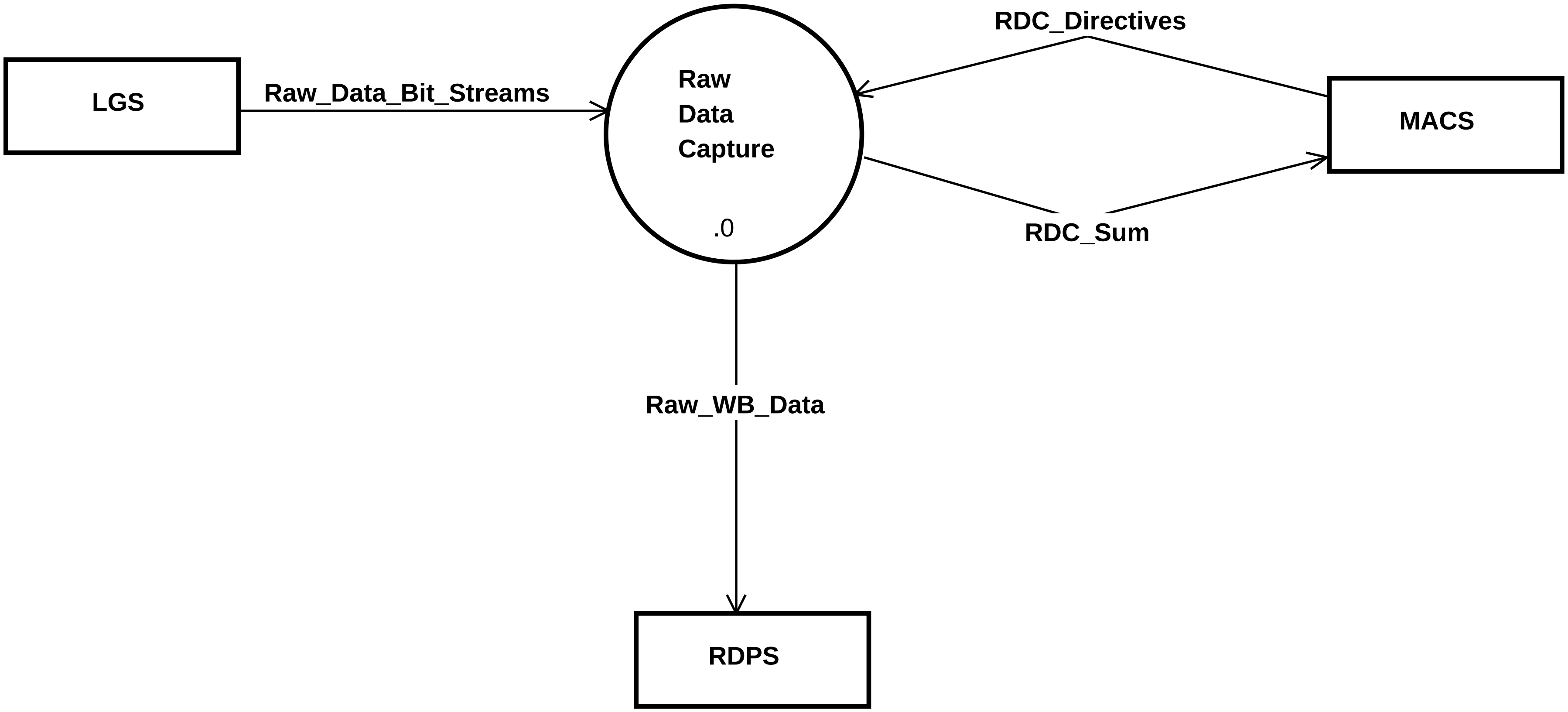
3.1.3 Functional Description

Figure 3-2 contains the RDCS's level 0 data flow diagram. The diagram shows the RDCS's primary functions. Those functions are described in the subsections below.

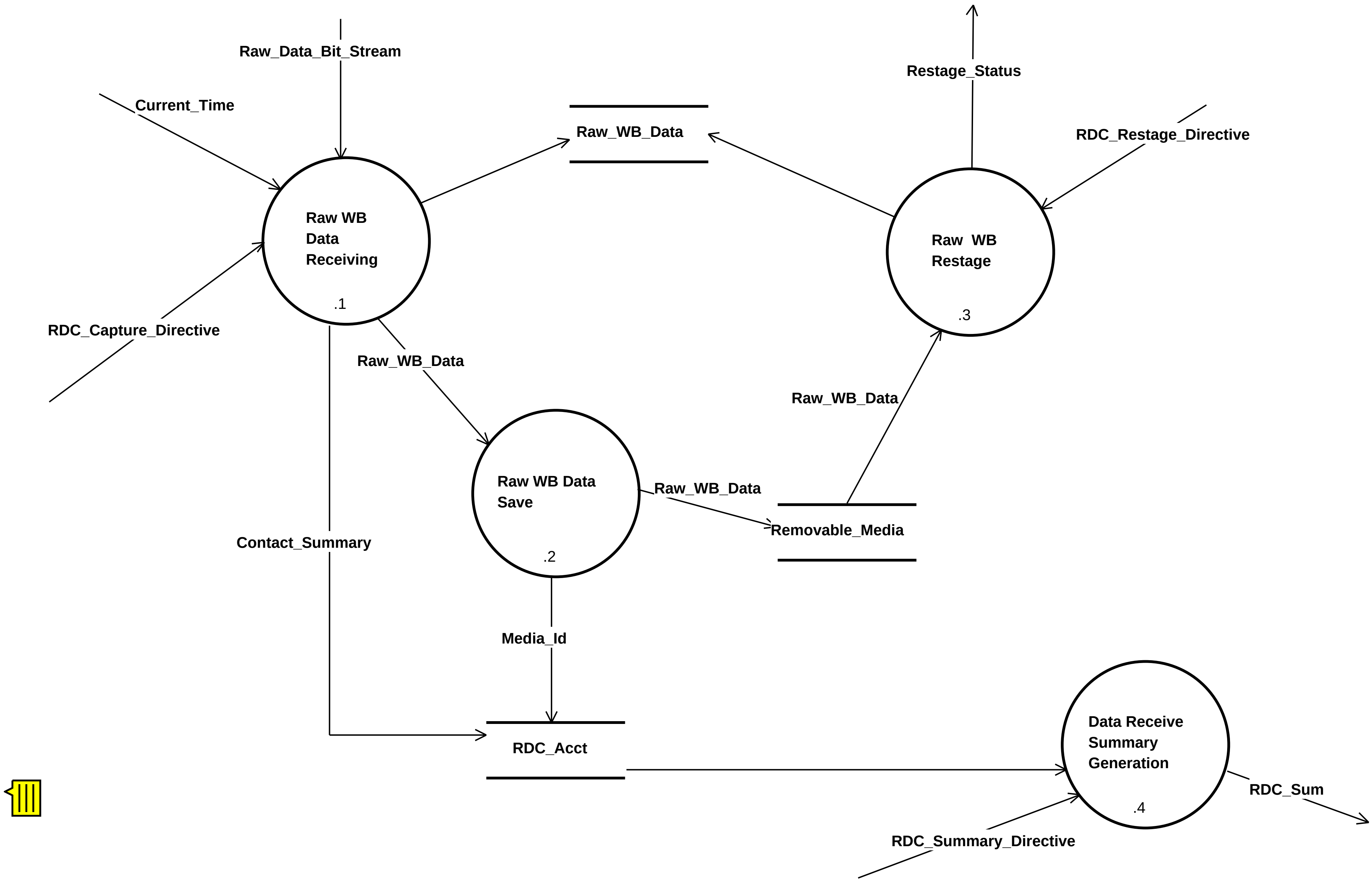
3.1.3.1 Raw WB Data Receiving

The Raw WB Data Receiving function accepts a raw data bit stream for a single LGS channel from the LGS and outputs the stream as a byte stream data set (Raw_WB_Data) to the Raw Wide Band Data data store and to the Raw WB Data Save function. Raw WB Data Receiving captures all contents of the LGS data line between the time it receives a data capture directive (RDC_Capture_Directive) to start capture from the MACS and the time it receives a data capture directive to stop capture. Raw WB Data Receiving notes the time of receipt of the start and stop directives by reference to the

1.11;2
RDCS_Context_Diagram



1.1;14
Raw Data Capture



operating system time (Current_Time). At the end of the contact period, the function outputs a contact summary (Contact_Summary) describing the contact to the RDC_Acct data store.

3.1.3.2 Raw WB Data Save

The Raw WB Data Save function accepts a raw wideband data set (Raw_WB_Data) from the Raw WB Data Receiving function and writes the data set to removable media.

3.1.3.3 Raw WB Restage

The Raw WB Restage function accepts a directive (RDC_Restage_Directive) specifying a raw wideband data set to be restaged, copies the data set from the Removable_Media data store to the Raw_WB_Data data store, and outputs a message (Restage_Status) describing the result of the requested operation.

3.1.3.4 Data Receive Summary Generation

The Data Receive Summary Generation function accepts a contact channel ID (RDC_Summary_Directive) included in the directives from the MACS, generates a data receive summary based on receive data accounting information from the RDC_Acct data store, and outputs the report (Data_Receive_Summary) to the MACS for display and printing.

3.1.4 Data

This section describes the data flows and data stores appearing in Figures 3-1 and 3-2.

Contact_Summary: Aggregate accounting information for a single channel for a single contact period, consisting of the contact period start and stop times, received data volume, and received data volume in approximate number of Landsat 7 scenes.

Data_Receive_Summary: A report containing a Contact_Summary for a specified raw wideband data set.

Raw_Data_Bit_Stream: Serial bit stream for a single LGS channel. The stream consists of a clock and data signal with clock always present. Note that the stream is continuous and is segmented into contact periods only by the start and stop of data capture. Clock time is an open issue as described in section 2.4.

Raw_WB_Data: A data set containing the subset of the raw data bit stream captured during the interval between the receipt of start and stop data capture directives by the Raw WB Data Receive function. The byte stream contains unvalidated CADUs, CADU fragments, and noise bits in any quantity and order. CADUs are not guaranteed to be byte aligned, i.e. a CADU frame synchronization pattern need not begin on a byte boundary. Noise bits may appear before and after a contact period's actual data and may appear within a contact period during a temporary loss of contact.

RDC_Capture_Directive: A directive to start or stop raw wideband data capture.

RDC_Directives: A directive from the MACS, including RDC_Capture_Directive, RDC_Restage_Directive, and RDC_Restage_Directive.

RDC_Restage_Directive: A directive to restage a raw wideband data set, identifies a data set to be restaged.

RDC_Summary_Directive: A directive to generate a data receive summary, identifies a data set for which the report is to be generated.

RDC_Sum: Summary information output to the MACS, either a Data_Receive_Summary or a Restage_Status.

Removable Media: The collection of raw wideband data sets stored on removable media.

Restage_Status: A message stating the restaging disposition of a raw wideband data set. It consists of a Contact Channel ID identifying the data set and a status value, either that the data set has been restaged or that the data set is not available.

Current_Time: The operating system time.

3.1.5 Subsystem Hardware

An instance of the RDCS executes on the Data Process HWCI of each LPS string. The Serial-to-parallel Board HWC in each string converts the raw data bit stream to a byte stream. The Mizar MZ 7772 DSP Board transfers the byte stream to the Raw Data Capture HWCI. The LPS string's 60-day Data Storage HWCI is used to move captured data between staging storage and removable media. LPS operators control the subsystem through the Operations Interface HWCI.

3.1.6 Subsystem Software

The RDCS software includes custom application code. The RDCS uses the Oracle DBMS SWCI to manage raw wideband data set quality and accounting information. The RDCS uses the Mizar MZ7772 DSP Board SWCI to download and execute custom application code on the Mizar MZ7772 DSP Board HWCI. The RDCS uses the RAID Array Device Interface system support SWCI to write raw wideband data to the Raw Data Storage HWCI.

3.2 Raw Data Processing Subsystem (RDPS)

The Raw Data Processing Subsystem (RDPS) extracts and validates CCSDS VCDUs from a raw wide band data set specified by the MACS. The RDPS synchronizes on CADUs within the raw byte stream, removes fill CADUs, validates embedded VCDUs and their fields using appropriate Error Detection and Correction (EDAC) algorithms, and checks for changes in the VCID in the VCDU sequence. The RDPS annotates each VCDU with quality indicators to indicate the results of its processing and outputs the annotated VCDUs. Data units that fail validation are also stored in a separate file. During its processing, the RDPS accumulates counts of synchronization and EDAC errors for the contact period. The RDPS also computes and stores a Bit Error Rate (BER) for the data set based on the detected bit errors during VCDU validation and the number of CADUs extracted from the data set after the first sync was established.

3.2.1 Requirements Allocation

Table 3.2-1 provides the RDPS requirements map. The complete mapping of LPS system requirements to subsystems is provided in Appendix A.

3.2.2 Interfaces

Figure 3-3 illustrates the RDPS's system context and external interfaces. The RDPS accepts directives (RDP_Directive) either to identify a raw wideband data set to be processed or to generate a return link quality and accounting report and updated CCSDS processing parameters (CCSDS_Parms) from the MACS. The RDPS accepts a raw wideband data set (Raw_WB_Data) from the RDCS. The RDPS receives updated CCSDS processing parameters (CCSDS_Parms) from the MACS.

The RDPS outputs annotated VCDUs (Annotated_VCDUs) to the MFPS. The RDPS outputs a return link quality and accounting report (RDP_Sum) to the MACS.

Table 3-2: RDPS Requirements Map (1 of 3)

Number	Requirement Description
3.1.1	LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.
3.1.2	LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.
3.1.3	LPS shall provide the capability to receive, record and process 4 simultaneous wideband data inputs from the LGS, and deliver LPS output files.
3.1.4	LPS shall process wideband data inputs from LGS on a Landsat 7 contact period (return link wideband data recording session) basis.
3.1.6	LPS shall generate Landsat 7 return link quality and accounting data on a Landsat 7 contact period basis for each wideband data input.
3.1.10	The LPS shall provide an interactive intervention capability to detect and correct abnormal system conditions during LPS data capture and processing activities.
3.1.10.3	LPS shall provide the capability to generate and report LPS error messages
3.1.10.6	LPS shall provide the capability to test LPS functions and external interfaces.
3.1.10.7	LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.
3.1.10.8	LPS shall provide the capability to support end-to-end testing of LPS functions.
3.1.11	LPS shall provide the capability to control LPS operations.
3.1.12	LPS shall provide the capability to monitor LPS operations.
3.1.19	LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.
3.1.20	LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.
3.1.21	LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.
3.1.22	LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.
3.1.23	LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.

Table 3-2: RDPS Requirements Map (2 of 3)

3.3.2.1	LPS shall perform Consultative Committee for Space Data Systems (CCSDS) Advanced Orbiting Systems (AOS) Grade-3 service on all received wideband Channel Access Data Units (CADUs) formatted in accordance with ...
3.3.2.2	LPS shall perform CADU synchronization on all received wideband data.
3.3.2.3	LPS shall provide the capability to detect and to synchronize on normal and inverted polarity wideband data.
3.3.2.4	LPS shall utilize a Search/Check/Lock/Flywheel strategy for synchronization using the following selectable tolerances...
3.3.2.5	LPS shall provide the capability to invert all bits of each CADU detected to have inverted polarity.
3.3.2.6	LPS shall provide the capability to correct bit slips, selectable between 0 and plus or minus 3 bits, in a CADU, by truncating or padding to the proper length.
3.3.2.7	LPS shall provide the capability to perform pseudo-random (PN) decoding of all received Virtual Channel Data Units (VCDUs) in accordance with...
3.3.2.8	LPS shall provide the capability to store all CADUs which have failed CCSDS Grade-3 service processing, on a Landsat 7 contact period basis.
3.3.2.9	LPS shall provide the capability to perform Bose-Chaudhuri-Hocquenghem (BCH) error detection and correction on the mission data zone contained in the VCDU (CCSDS processed data) in accordance with the Landsat 7 spacecraft data format information ...
3.3.2.9.1	LPS shall provide the capability to perform BCH error detection and correction on the data pointer zone contained in the VCDU (CCSDS processed data) in accordance with the Landsat 7 spacecraft data format information ...
3.3.2.10	LPS shall provide the capability to store all CADUs which have failed BCH error detection and correction, on a Landsat 7 contact period basis.
3.3.2.12	LPS shall provide the capability to delete fill VCDUs.
3.3.2.13	LPS shall provide the capability to collect and store Landsat 7 return link (input) quality and accounting data...
3.3.6.1	LPS shall provide the capability to generate and modify LPS set-up tables from operator inputs.
3.3.6.2	LPS shall provide the capability to collect and report Landsat 7 return link quality and accounting data for each wideband data input on a Landsat 7 contact period basis.
3.3.6.8	LPS shall provide the capability to manually override the LPS automated functions.

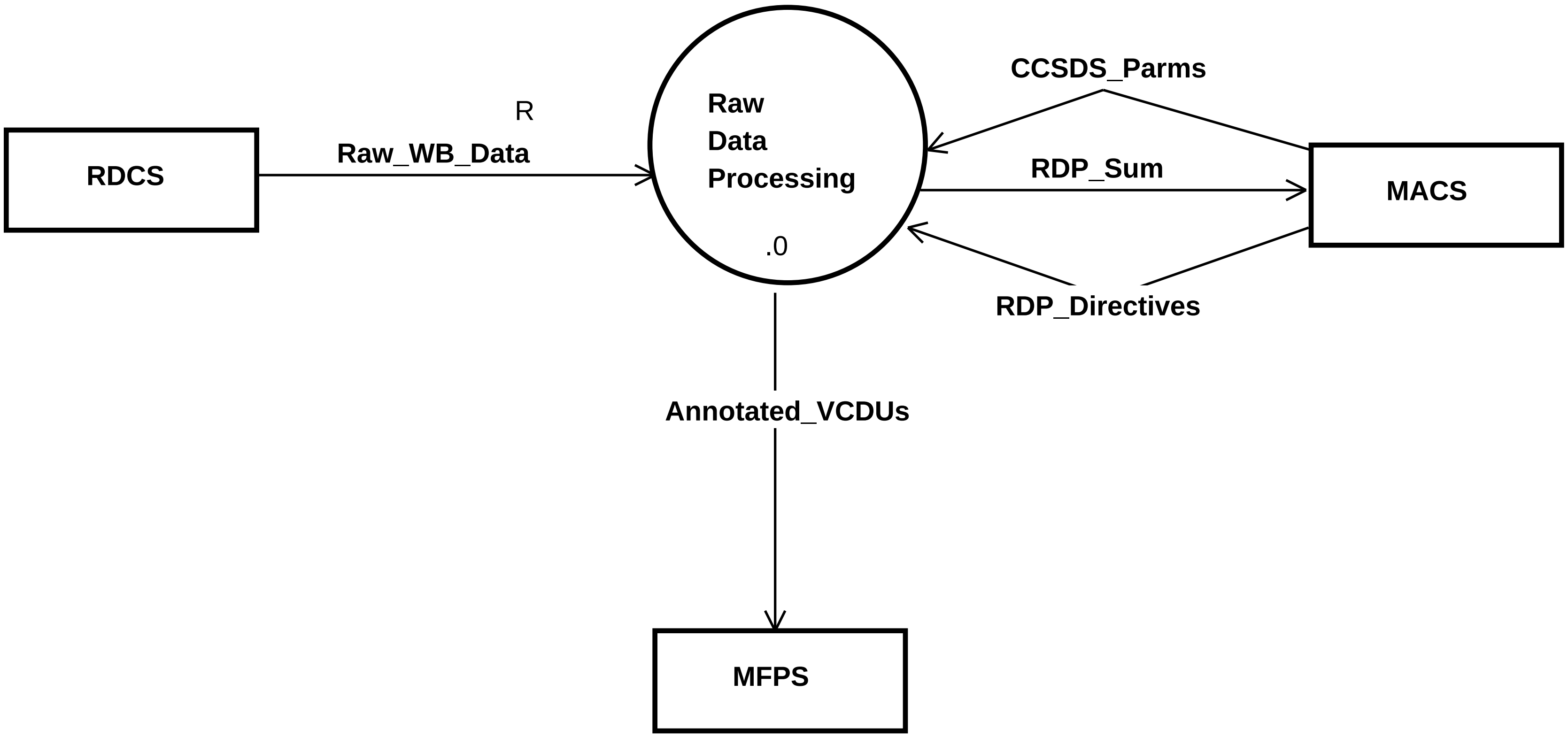
Table 3-2: RDPS Requirements Map (3 of 3)

3.3.6.9	LPS shall provide the capability to selectively enable and/or disable each of the following functions: … b. Generate Level 0R Files …
4.1.3	LPS shall provide the capability to receive and process the equivalent of 250 Landsat 7 ETM+ scenes of wideband data per day (approximately 100 GB per day).
4.1.4	LPS shall provide the capability to receive and process the daily volume of wideband data within 16 hours of its receipt at LPS.
4.1.5	LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data ...
4.1.6	LPS shall provide the capability to process received wideband data at an average aggregate rate of 12 megabits per second (Mbps) (Includes 10% of overhead due to reprocessing).
4.1.8	LPS shall introduce no more than one bit error in 10^9 bits.
4.1.9	LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a BER of one bit error in 10^5 bits, without loss of level zero processed data and without retransmission
4.3.3	LPS shall provide the capability to retrieve retained wideband data at rates equal to or greater than 7.5 Mbps for each LPS input.
4.4.1	LPS shall provide an Operational Availability (A_o) of 0.96 or better for all processing functions.
4.4.2	LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.
4.4.3	any LPS time to restore shall not exceed twice the required MTTRes in 99 percent of failure occurrences.

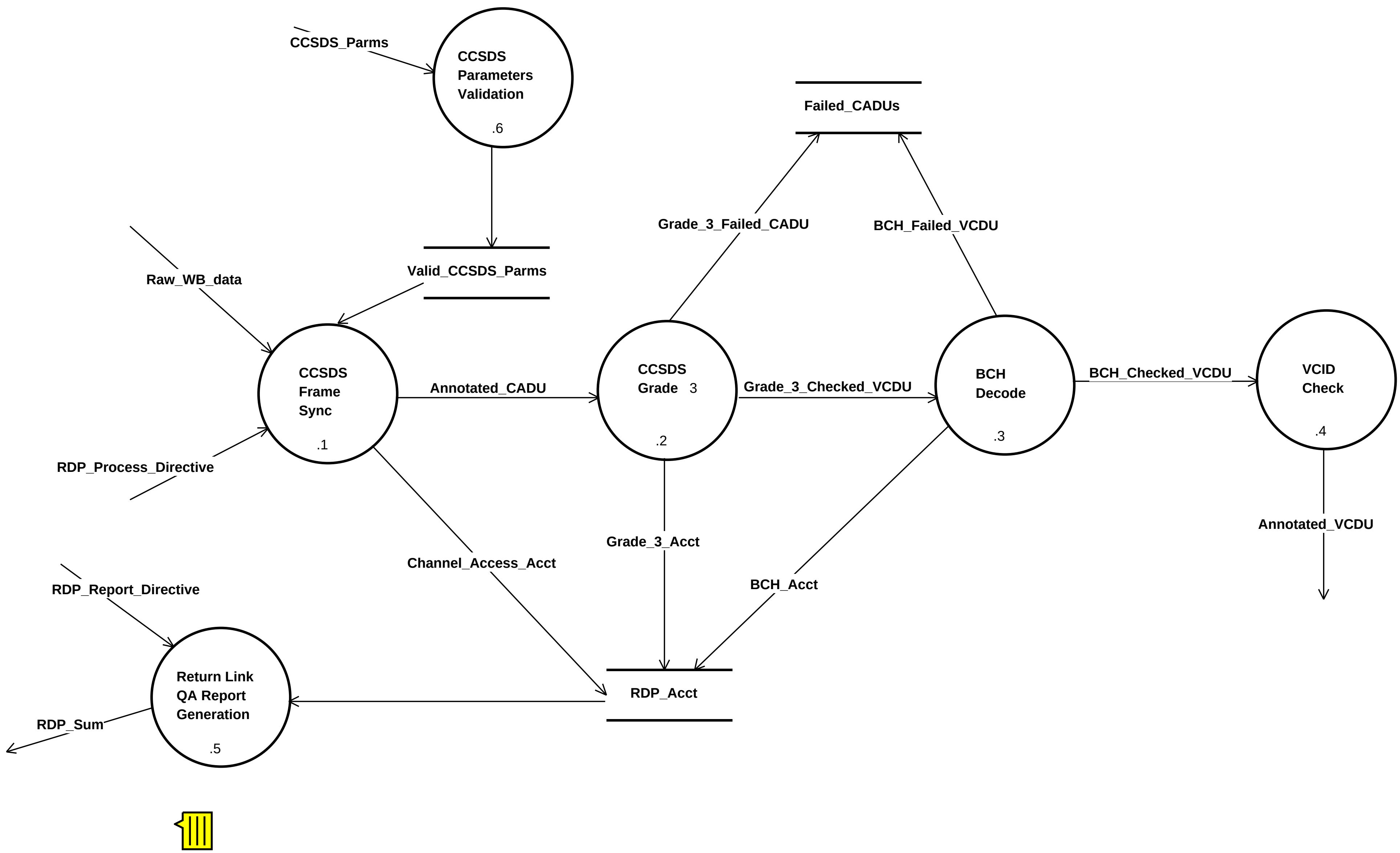
3.2.3 Functional Description

Figure 3-4 contains the RDPS's level 0 data flow diagram. The diagram shows the RDPS's primary functions. Those functions are described in the subsections below.

1.21;2
RDPS_Context_Diagram



1.2;14
Raw Data Processing



3.2.3.1 CCSDS Frame Sync

The CCSDS Frame Sync function accepts a RDP_Process_Directive specifying a raw wideband data set to be processed. The function retrieves the specified data set (Raw_WB_Data) from the Raw_WB_Data data store managed by the RDCS. The function locates CADUs within the unaligned raw wide band data set and outputs these, suitably transformed and annotated, for further CCSDS processing.

The function performs the following operations on the specified data set.

- Locating CADU sync patterns (normal or inverted) within the raw wide band data byte stream to segment the byte stream into a sequence of CADUs.
- Inverting the polarity of CADUs with inverted polarity.
- PN decoding the polarity normalized CADUs.
- Detecting and correcting bit slips.

Synchronization is controlled by operator settable parameters, retrieved from the Valid_CCSDS_Parms data store, that govern synchronization tolerances and bit slip correction extent.

The CCSDS Frame Sync function outputs an annotated CADU (Annotated_CADU – the CADU plus frame and bit synchronization quality indicators and an end of data set indicator marking the final CADU for the contact period) for each synchronized CADU. The CCSDS Frame Sync function outputs channel access quality and accounting information (Channel_Access_Acct) for the data set to the RDP_Acct data store.

3.2.3.2 CCSDS Grade 3

The CCSDS Grade 3 function accepts annotated CADUs output by the CCSDS Frame Sync function and generates grade 3 checked VCDUs (Grade_3_Checked_VCDUs). CCSDS Grade 3 includes the following subfunctions.

- Computing a 16 bit CRC checksum in conformance with Applicable Document 1 and comparing the result with the CRC code contained in the VCDU Trailer Error Control Field.
- Performing R-S EDAC on the VCDU header.
- Detecting fill CADUs.

CCSDS Grade 3 discards fill CADUs. For each non-fill CADU, CCSDS Grade 3 outputs a grade 3 checked VCDU (Grade_3_Checked_VCDUs – annotated CADU plus CRC check result and Reed-Solomon check result) to the BCH Decode function. For each non-fill CADU containing uncorrectable errors, CCSDS Grade 3 also outputs a grade 3 checked CADU (Grade_3_Failed_CADU) to the failed_CADUs data store in such a way as to allow retrieval on a contact period basis. CCSDS Grade 3 outputs Grade 3 quality and accounting information (Grade_3_Acct) for the data set to the RDP_Acct data store.

3.2.3.3 BCH Decode

The BCH Decode function performs BCH EDAC on the Mission Data field and Data Pointer field of the grade 3 checked VCDUs (Grade_3_Checked_VCDUs) it accepts from the CCSDS Grade 3 function. For each VCDU, BCH Decode outputs a BCH checked VCDU (BCH_Checked_VCDU – the grade 3 checked VCDU plus mission data and data pointer field check quality indicators) to the VCID Check function. For each VCDU with uncorrectable errors, BCH Decode outputs a BCH checked VCDU (BCH_Failed_VCDU) to the failed_CADUs data store in such a way as to allow retrieval on a contact period basis. BCH Decode also outputs BCH field EDC quality and accounting information (BCH_Acct) to the RDP_Acct data store.

3.2.3.4 VCID Check

The VCID Check function accepts a BCH checked VCDU (BCH_Checked_VCDU) from the BCH Decode function and outputs an annotated VCDU (Annotated_VCDU) with a VCID change flag value that indicates whether the VCID for this VCDU is identical to the VCID of the last accepted VCDU.

3.2.3.5 Return Link QA Report Generation

The Return Link QA Report Generation function accepts a RDP_Report_Directive specifying a processed raw wideband data set, quality and accounting information for the data set from the RDP_Acct data store, computes the approximate number of ETM+ scenes based on the extracted count of received CADUs in RDP_Acct and the number of CADUs per scene (a constant), computes the approximate Bit Error Rate (BER) as the ratio of the sum of BCH and CRC errors to total data volume in bits, combines the extracted and computed information into a report and outputs the report (RDP_Sum).

3.2.3.7 CCSDS Parameters Validation

The CCSDS Parameters Processing function accepts CCSDS processing parameters (CCSDS_Parms) from the MACS, transforms these into the subsystem's internal format (if necessary), validates the parameters, and stores validated parameters in the Valid_CCSDS_Parms data store.

3.2.4 Data

This section describes the data flows and data stores appearing in Figures 3-3 and 3-4.

Annotated_CADU: A CCSDS Channel Access Data Unit plus frame synchronization and a bit slip quality indicators and an end of data set indicator marking the final CADU for the contact period.

Annotated_VCDU: A BCH_Checked_VCDU plus a VCID change flag.

BCH_Acct: Aggregate information on the number of Mission Data and Data Pointer Field BCH errors encountered in a data set, including counts of CADUs with BCH corrected errors and of CADUs with BCH uncorrected errors.

BCH_Checked_VCDU: A Grade_3_Checked VCDU plus Mission Data Field and Data Pointer Field BCH check quality indicators.

BCH_Failed_VCDU: A BCH_Checked_VCDU with either or both of its Mission Data Field and Data Pointer Field BCH check quality indicators indicating uncorrectable errors.

CCSDS_Parms: Parameters that control CCSDS frame synchronization and bit slip correction: search tolerance (1-3 CADUs), check tolerance (0-3 CADUs), flywheel tolerance (0-3 CADUs), CADU synchronization marker check error tolerance (0-3 bits), CADU synchronization lock error tolerance (0-3) bits, and bit slip correction extent (0-±3 bits).

Channel_Access_Acct: Quality and accounting information derived from CCSDS processing on the channel access layer: CADU synchronization information, count of CADUs with synchronization errors, count of received CADUs, count of flywheel CADUs, count of missing CADUs.

RDP_Directives: Directives from the MACS, including RDP_Process_Directives and RDP_Report_Directives.

RDP_Process_Directive: A directive to process a specified raw wideband data set.

RDP_Report_Directive: A directive to produce a return link quality and accounting report for a specified processed raw wideband data set.

Failed_CADUs: The set of Grade_3_Failed CADUs and BCH_Failed_CADUs for each data set processed by the RDPS and stored in such a way as to allow retrieval on a contact period basis.

Grade_3_Acct: Aggregate information on the CCSDS virtual channel layer, including count of correctable VCDU headers by VCDU ID, count of uncorrectable VCDU headers, and count of CADUs with CRC errors.

Grade_3_Checked_VCDU: An Annotated_CADU plus VCDU CRC and VCDU header R-S EDAC quality indicators.

Grade_3_Failed_CADU: A Grade_3_Checked_VCDU with either or both of its VCDU CRC and VCDU header R-S EDAC quality indicators indicating uncorrectable errors.

Raw_WB_Data: See the description in section 3.1.4.

RDP_Acct: Aggregate information summarizing the CCSDS Grade 3 quality of a raw wide band data set (Raw_WB_Data), including Channel_Access_Acct, Grade_3_Acct, and BCH_Acct.

RDP_Sum: A return link quality and accounting report containing the RDP_Acct data store's entries for a specified raw wideband data set.

Valid_CCSDS_Parms: CCSDS_Parms that have been validated and stored for use in processing.

3.2.5 Subsystem Hardware

An instance of the RDPS executes on the Data Process HWCI of each LPS string. The RDPS reads raw wideband data sets from the Raw Data Capture HWCI. LPS operators control the subsystem through the Operations Interface HWCI.

3.2.6 Subsystem Software

The RDPS software includes custom application code. The BCH prototype is being investigated for possible reuse. The reuse possibility and statistics on reuse levels will be included in the software design phase.

The RDPS uses the Oracle DBMS system support SWCI to manage return link quality and accounting information. The RDPS uses the IRIX operating system and RAID Array Device Interface system support SWCIs to retrieve raw wideband data sets.

3.3 Major Frame Processing Subsystem (MFPS)

The MFPS receives annotated VCDUs. The MFPS performs all processing of the VCDUs on a major frame basis. Major frame identification consists of processing each minor frame according to its respective format as specified in Applicable Document 3. It is within this subsystem that the major frame time is extracted and verified. It also performs the band deinterleaving and alignment. The MFPS extracts the PCD byte and sends it to the PCD processing subsystem (PCDS). The MFPS determines the sub-interval, the result of which is sent to several subsystems. When the end of a sub-interval is detected, all files formed on a sub-interval basis are closed.

3.3.1 Requirements Allocation

Table 3-3 provides the MFPS requirements map. The complete mapping of the LPS system requirements to subsystems is provided in Appendix A.

3.3.2 Interfaces

Figure 3-5 illustrates the MFPS's context and external interfaces. The RDPS provides annotated VCDUs (Annotated_VCDUs) to the MFPS. The MACS provides the sensor alignment information (Sensor_Alignment_Info) that is necessary for integer-pixel alignment. The MFPS produces three files (MFP_Acct) that interface with the MACS: 1) the major frame quality and accounting file, 2) the calibration accounting file, and 3) the MSCD accounting file. The MFPS also sends the sub-interval time range (Sub_Intv) to the MACS. The calibration data file (Cal_File) and the MSCD file (MSCD_File) are stored to disk until transferred to the LP-DAAC. The PCD Subsystem (PCDS) receives from the MFPS the major frame time (Major_Frame_Time), the sub-interval time range (Sub_Intv), and the PCD bytes (PCD_Bytes) extracted from the VCDU status field. The Image Data Processing Subsystem(IDPS) receives the location of the aligned bands (Aligned_Bands) and the sub-interval time range (Sub_Intv).

There is no direct interface with an operator. However, it is necessary for an operator to interface with the MACS so that the MFPS can receive the sensor alignment information. All accounting information generated from the MFPS is sent to the MACS for display and/or printing.

Table 3-3: MFPS Requirements Map (1 of 3)

Number	Requirement Description
3.1.1	LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.
3.1.2	LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.
3.1.3	LPS shall provide the capability to receive, record and process 4 simultaneous wideband data inputs from the LGS, and deliver LPS output files.
3.1.5	LPS shall process wideband data to generate LPS output files on a received sub-interval basis.
3.1.7	LPS shall generate Level 0R quality and accounting data on a sub-interval basis for each LPS wideband data input.
3.1.10	The LPS shall provide an interactive intervention capability to detect and correct abnormal system conditions during LPS data capture and processing activities.
3.1.10.6	LPS shall provide the capability to test LPS functions and external interfaces.
3.1.10.7	LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.
3.1.10.8	LPS shall provide the capability to support end-to-end testing of LPS functions.
3.1.19	LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.
3.1.20	LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.
3.1.21	LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.
3.1.22	LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.
3.1.23	LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.
3.3.2.11	LPS shall start a new sub-interval on detection of a change in the VCID.
3.3.2.14	LPS shall locate ETM+ minor frames in each received VCDU ...
3.3.2.15	LPS shall perform ETM+ major frame synchronization using ETM+ minor frames...
3.3.2.16	LPS shall provide the capability to band deinterleave Format 1 ETM+ data ...

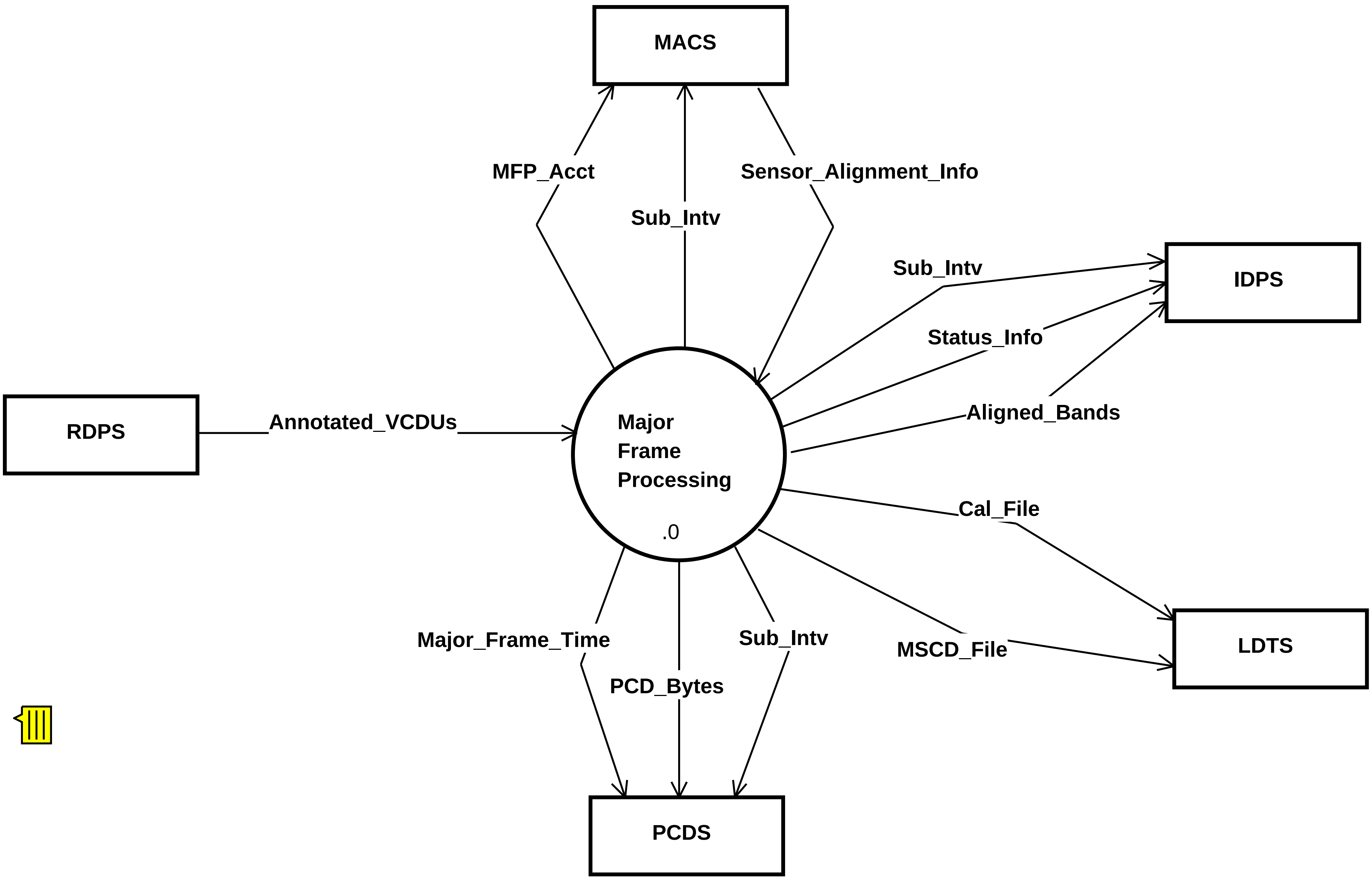
Table 3-3: MFPS Requirements Map (2 of 3)

3.3.2.17	LPS shall provide the capability to band deinterleave Format 2 ETM+ data ...
3.3.2.18	LPS shall provide the capability to reverse the order of data for ETM+ reverse scans.
3.3.2.19	LPS shall provide the capability to fill the following Landsat 7 data with preselected values...
3.3.2.20	LPS shall provide the capability to extract Mirror Scan Correction Data (MSCD) on an ETM+ major frame basis.
3.3.2.21	LPS shall provide the capability to extract calibration data on an ETM+ major frame basis.
3.3.2.22	LPS shall provide the capability to perform integer-pixel alignment for each ETM+ band using sensor alignment information.
3.3.2.23	LPS shall provide the capability to determine ETM+ data sub-intervals.
3.3.2.24	LPS shall provide the capability to process wideband data to level 0R.
3.3.2.25	LPS shall provide the capability to generate the following correlated Level 0R file(s) on a received sub-interval basis...
3.3.2.26	LPS shall generate Level 0R quality and accounting data, including the following information, on a sub-interval basis...
3.3.2.28	LPS shall append the status data contained in the VCDU mission data zone, as specified in Applicable Document 3, to Level 0R files(s) on a major frame basis.
3.3.4.2	LPS shall provide the capability to fill missing PCD data.
3.3.6.1	LPS shall provide the capability to generate and modify LPS set-up tables from operator inputs.
3.3.6.3	LPS shall provide the capability to collect and report Level 0R quality and accounting data for each wideband data input on a sub-interval.
3.3.6.9	LPS shall provide the capability to selectively enable and/or disable each of the following functions: … b. Generate Level 0R Files …
4.1.3	LPS shall provide the capability to receive and process the equivalent of 250 Landsat 7 ETM+ scenes of wideband data per day (approximately 100 GB per day).
4.1.4	LPS shall provide the capability to receive and process the daily volume of wideband data within 16 hours of its receipt at LPS.
4.1.5	LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data ...

Table 3-3: MFPS Requirements Map (3 of 3)

4.1.6	LPS shall provide the capability to process received wideband data at an average aggregate rate of 12 megabits per second (Mbps) (Includes 10% of overhead due to reprocessing).
4.1.8	LPS shall introduce no more than one bit error in 10^9 bits.
4.1.9	LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a BER of one bit error in 10^5 bits, without loss of level zero processed data and without retransmission.
4.4.1	LPS shall provide an Operational Availability (A_o) of 0.96 or better for all processing functions.
4.4.2	LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.
4.4.3	Any LPS time to restore shall not exceed twice the required MTTRes in 99 percent of failure occurrences.

1.31;3
MFPS_Context_Diagram



3.3.3 Functional Description

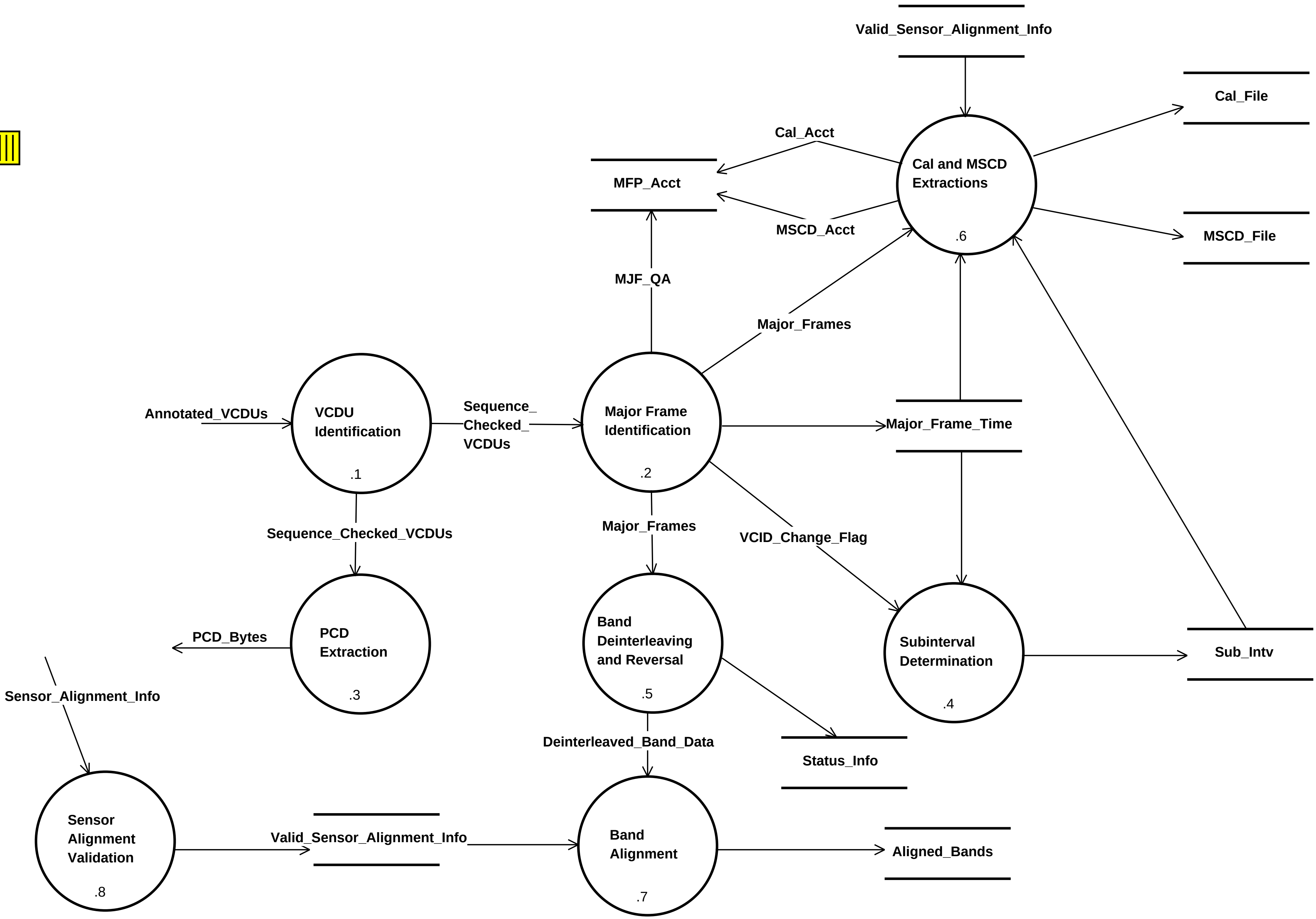
Figure 3-6 contains the MFPS's level 0 data flow diagram. The diagram shows the MFPS's primary functions. Those functions are described in the subsections below.

3.3.3.1 VCDU Identification

The VCDU Identification function uses the scan bit located in the PCD/status field of the annotated VCDU (Annotated_VCDU) as an indicator to determine the start of a major frame. The scan bit toggles between 0 and 1. When the scan bit changes, the current major frame ends and a new major frame begins. For each current major frame the processing remains in this function until all VCDUs with the current scan bit value are collected. An upper limit exists for the number of VCDUs that will be collected for a major frame. If this is exceeded, information about the VCDUs is logged to a trouble file, and the major frame VCDU collection begins anew. Once an acceptable major frame is detected the VCDU sequence counter for each VCDU is checked in order to identify any possible missing VCDUs and distinguish these from a sequence counter error. If VCDUs are, in fact, missing, the number of missing VCDUs along with their location within the major frame are sent to the Major Frame Identification function. This information is in the form of sequence checked VCDUs (Sequence_Checked_VCDUs). The PCD Extraction function receives the same data.

1.3;17

Major Frame Processing



3.3.3.2 Major Frame Identification

The Major Frame Identification function searches the minor frames within the sequence checked VCDUs (Secquence_Checked_VCDUs) for the major frame synchronization. When this is found the major frame time is extracted and calculated from the minor frames following the synchronization code word. Afterwards, each minor frame is checked in sequence for the major frame end of line (EOL) indicator. The minor frames containing the scene data locations are stored during the search for EOL. If the major frame sync cannot be found, then the set of VCDUs are sent to a major frame trouble file (not shown). If a major frame is declared the location of the scene data minor frames (Major_Frames) is passed to the Band Deinterleave Reversal function and the Cal and MSCD Extraction function. (The scene data here refers to the format type of the minor frame not to the mission data information collected on a scene basis.) The major frame time is output to the Major_Frame_Time data store. A file (MPF_Acct) containing the major frame processing quality and accounting information (MJF_QA) is generated. The VCID is extracted from the VCDU and sent to the sub-interval determination function.

3.3.3.3 PCD Extraction

The PCD Extraction function receives the sequence checked VCDUs (Sequence_Checked_VCDUs) after the VCDU identification function. The PCD bytes from the VCDU status field are extracted from the VCDUs that reside in shared memory. These bytes (PCD_Bytes) are sent to the PCDS. If VCDUs are declared missing, four bytes consisting of fill data are sent to the PCDS for each missing VCDU.

3.3.3.4 Subinterval Determination

The Subinterval Determination function calculates the difference between the previous major frame time and the current major frame time. From this difference either a sub-interval is detected or only a time gap within a sub-interval. A sub-interval will also be declared if a VCID change (VCID_Change_Flag) is detected. Within the MFPS the sub-interval time range (Sub_Intv) is sent to the Cal and MSCD Extraction function. External to this subsystem the sub-interval time range is used by the MACS, the PCDS, and the IDPS.

3.3.3.5 Band Deinterleaving and Reversal

The Band Deinterleaving and Reversal function deinterleaves the bytes from the major frames (Major_Frames) containing the scene data. From these bytes the spectral bands for a major frame are formed according to the ETM+ scene data format 1 or 2 as outlined in Applicable Document 3. If the scan bit value (as described in 3.3.3.1) is 0, then the order of the data must be reversed. After all scene data for a major frame is deinterleaved the new deinterleaved data (DeInterleaved_Band_Data) is passed to the band alignment function. If VCDUs are declared missing, DeInterleaved_Band_Data includes fill data for each missing VCDU. The status data will be extracted from the associated VCDUs and stored in Status_Info, which is used by the IDPS.

3.3.3.6 Cal & MSCD Extraction

The Cal & MSCD Extraction function extracts minor frames that contain the calibration data and mirror scan correction data from the major frame (Major_Frames). Error checking on the MSCD is performed by the majority vote method. Detected errors are included in the quality and accounting information (MFP_Acct and MSCD_Acct). The data, which is used by the LDTS, is then stored in their respective files (Cal_File and MSCD_File). The function performs odd and even integer pixel alignment on the calibration data using the sensor alignment information (Valid_Sensor_Alignment_Info). If VCDUs are declared missing, Cal_File and MSCD_File entries include fill data for each missing VCDU. The quality and accounting information (MFP_Acct and MSCD_Acct) is generated with respect to these data files. Sub_Intv is used to group outputs by sub-interval.

3.3.3.7 Band Alignment

The Band Alignment function performs odd and even integer pixel alignment on the deinterleaved band data (DeInterleaved_Band_Data) using the sensor alignment information (Valid_Sensor_Alignment_Info) received from the MACS . The aligned band data (Aligned_Bands) is then passed to the IDPS.

3.3.3.8 Sensor Alignment Validation

The Sensor Alignment Processing function requests the sensor alignment information (Sensor_Alignment_Info) from the MACS, transforms the information into the subsystem's internal format (if necessary), validates the information, and stores the validated information in the Valid_Sensor_Alignment_Info data store.

3.3.4 Data

This section describes the data flows and data stores appearing in Figures 3-5 and 3-6.

Aligned_Bands: Band data upon which odd/even integer pixel alignment has been performed.

Annotated_VCDUs: Refer to the RDPS.

Cal_Acct: The quality and accounting information for the Cal_File. Information is collected on a major frame basis for a given sub-interval.

Cal_File: A file containing all of the calibration data received on a major frame basis for a given sub-interval.

Deinterleaved_Band_Data: All band data on a major frame basis that is deinterleaved according to band width. Data is reversed, if necessary.

Major_Frames: The set of VCDUs beginning with the current major frame synchronization and ending with the next major frame synchronization.

Major_Frame_Time: The time associated with one major frame. This time is extracted from minor frames two through seven. It is calculated according to the minor frame format as stated in Applicable Document 3.

MFP_Acct: All quality and accounting information that is received on a major frame basis for a given sub-interval. It consists of information on the major frame processing data, the calibration data and the MSCD

MJF_QA: The quality and accounting information for the MFPS calculated on a major frame basis for a given sub-interval.

MSCD_Acct: The quality and accounting information for the MSCD_File. Information is collected on a major frame basis for a given sub-interval.

MSCD_File: A file containing the Scan Line data extracted from the two minor frames following the End of Line Code in each major frame for a given sub-interval.

PCD_Bytes: The four bytes that are extracted from the PCD/Status field of the VCDU. These will contain fill, if necessary.

Sensor_Alignment_Info: Refer to the MACS.

Sequence_Checked_VCDUs: These VCDUs have been checked for sequence errors or missing VCDUs. The number of VCDUs missing is implicit within the Sequence_Checked_VCDUs. This information is necessary for any function that extracts data from these VCDUs. Fill data will be used as a replacement for all data that should have been extracted.

Status_Info: The status information extracted from the PCD/Status field of the VCDU.

Sub_Intv: The beginning and ending major frame times corresponding to a predefined sub-interval time range.

Valid_Sensor_Alignment_Info: Sensor_Alignment_Info that has been validated and stored for use in processing.

VCID_Change_Flag: A flag located in the VCDU to indicate that the VCID type has changed. A VCID change will operate as the end of a sub-interval.

3.3.5 Subsystem Hardware

The MFPS consists of UNIX-based computer systems for data processing and storage.

3.3.6 Subsystem Software

Due to the specific needs of the LPS the MFPS consists entirely of code written specifically for this project.

3.4 PCD Processing Subsystem (PCDS)

The PCD Processing Subsystem (PCDS) accepts the PCD Bytes (PCD_Bytes) from the Major Frame Processing Subsystem. PCDS uses the PCD_Bytes to extract the PCD information word. The information word is used to build PCD minor frames, which consist of 128 PCD information words. Once the PCD minor frames are built, PCDS uses the PCD minor frames to build PCD major frames. PCD major frames consist of 128 PCD minor frames which contain mission related telemetry describing the attitude, ephemeris, jitter and other data that describes the status of the spacecraft and the spacecraft's subsystems. The mission related telemetry provides the information needed to geometrically correct the ETM+ imagery.

The PCDS is responsible for determining the ETM+ scene identification as well as the Sun azimuth and elevation using the information contained in the PCD major frame. The scene identification is in accordance with the WRS scheme. In addition, the PCDS determines the status of the calibration door and extracts the drift time for each PCD major frame. The calibration door status is included in the PCD accounting file and the drift time (Drift_Time) is used by the Image Data Processing Subsystem (IDPS).

3.4.1 Requirements Allocation

Table 3-4 provides the PCDS requirements map. The complete mapping of LPS system requirements to subsystems is provided in Appendix A.

Table 3-4: PCDS Requirements (1 of 3)

Number	Requirement Description
3.1.1	LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.
3.1.2	LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.
3.1.3	LPS shall provide the capability to receive, record and process 4 simultaneous wideband data inputs from the LGS, and deliver LPS output files.
3.1.5	LPS shall process wideband data to generate LPS output files on a received sub-interval basis.
3.1.10	The LPS shall provide an interactive intervention capability to detect and correct abnormal system conditions during LPS data capture and processing activities.
3.1.10.6	LPS shall provide the capability to test LPS functions and external interfaces.
3.1.10.7	LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.
3.1.10.8	LPS shall provide the capability to support end-to-end testing of LPS functions.
3.1.19	LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.
3.1.20	LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.
3.1.21	LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.
3.1.22	LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.
3.1.23	LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.
3.3.2.24	LPS shall provide the capability to process wideband data to level 0R.
3.3.2.25	LPS shall provide the capability to generate the following correlated Level 0R file(s) on a received sub-interval basis...

Table 3-4: PCDS Requirements (2 of 3)

Number	Requirement Description
3.3.2.29	LPS shall provide the capability to identify the presence of calibration door activities using information extracted from the PCD.
3.3.4.1	LPS shall provide the capability to synchronize on PCD bytes for assembling PCD minor frames ...
3.3.4.2	LPS shall provide the capability to fill missing PCD data.
3.3.4.3	LPS shall provide the capability to assemble PCD major frames ...
3.3.4.4	LPS shall provide the capability to generate PCD file(s) on a sub-interval basis.
3.3.4.5	LPS shall provide the capability to collect and store PCD quality and accounting data on a sub-interval basis.
3.3.4.6	LPS shall provide the capability to collect and store processed PCD quality and accounting data on a sub-interval basis.
3.3.4.7	LPS shall provide the capability to perform ETM+ scene identification in accordance with the WRS scheme...
3.3.6.9	LPS shall provide the capability to selectively enable and/or disable each of the following functions: … b. Generate Level 0R Files …
4.1.3	LPS shall provide the capability to receive and process the equivalent of 250 Landsat 7 ETM+ scenes of wideband data per day (approximately 100 GB per day).
4.1.4	LPS shall provide the capability to receive and process the daily volume of wideband data within 16 (TBR) hours of its receipt at LPS.
4.1.5	LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data ...
4.1.6	LPS shall provide the capability to process received wideband data at an average aggregate rate of 12 megabits per second (Mbps) (Includes 10% of overhead due to reprocessing).
4.1.8	LPS shall introduce no more than one bit error in 10^9 bits.
4.1.9	LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a BER of one bit error in 10^5 bits, without loss of level zero processed data and without retransmission.
4.3.5	LPS shall provide the capability to identify ETM+ WRS scene within an accuracy of 15 meter.

Table 3-4: PCDS Requirements (3 of 3)

Number	Requirement Description
4.4.2	LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.
4.4.3	Any LPS time to restore shall not exceed twice the required MTTRes in 99 percent of failure occurrences.

3.4.2 Interfaces

The Major Frame Processing Subsystem (MFPS) provides the PCDS with four PCD Bytes (PCD_Bytes) which are extracted from the PCD/Status section of the VCDU. The four bytes consist of any combination of sync words(s), information word(s), and filler word(s) as outlined in Applicable Document 3. The information word(s) contain telemetry information regarding the status of the spacecraft and its subsystems, and is used to build PCD Minor Frames. In addition, the MFPS determines the sub-interval (Sub_Intv) which is needed by the PCDS to generate the PCD file (PCD_File) and the PCD accounting file (PCD_Acct) on a sub-interval basis. The Major_Frame_Time is provided by MFPS to be used to calculate the scene identification.

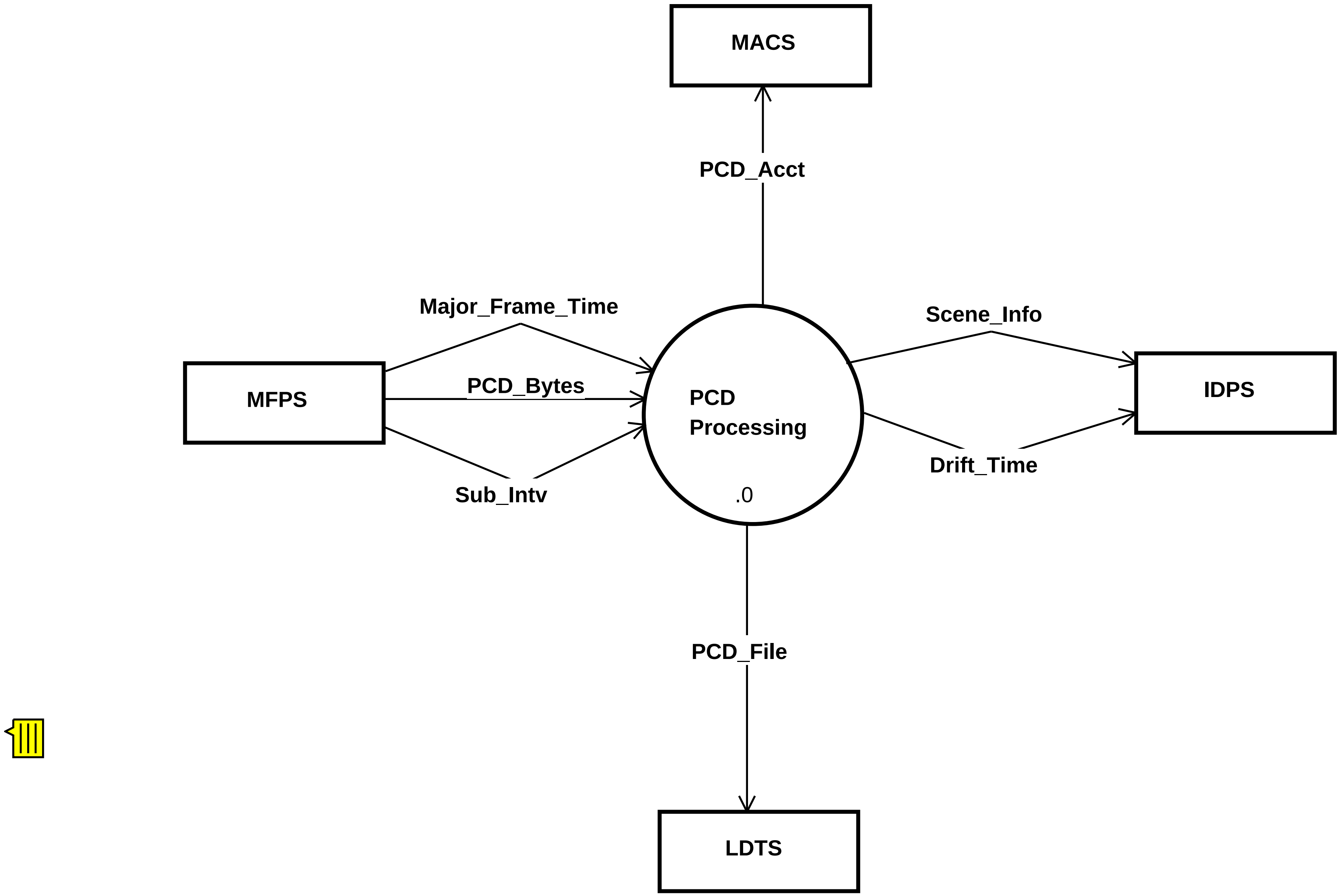
The WRS provides PCDS with the scheme that is necessary to determine the scene identification.

The drift time (Drift_Time) is extracted from each of the PCD Major Frames. The drift time is extracted, on a sub-interval basis, for use by the Image Data Processing Subsystem.

The PCDS generates the PCD file (PCD_File) for use by the LDTS. The PCD file contains the PCD major frames received during a sub-interval on a full PCD cycle basis. In addition, the PCDS is responsible for maintaining a PCD accounting file (PCD_Acct) for use by the MACS. The PCD accounting file (PCD_Acct) contains the statistics that are gathered from the processing of PCD_Bytes, the building of PCD minor and major frames, and the extraction and interpretation of information from the PCD major frames.

The PCDS calculates the scene identification and Sun azimuth and elevation (Scene_Info) for use by the Image Data Processing Subsystem (IDPS). The scene information is calculated using the attitude and ephemeris data from the PCD major frame, the ETM+_Major_Frame_Time, and based upon the WRS table data (Not Shown). The scene parameters are included in the PCD accounting file (PCD_Acct) for use by the MACS.

1.41;3
PCDS_Context_Diagram



3.4.3 Functional Description

Figure 3-8 contains the PCDS's level 0 data flow diagram. The diagram shows the PCDS's primary functions. Those functions are described in the subsections below.

3.4.3.1 PCD Bytes Processing

The PCD Bytes Processing function accepts four PCD Bytes (PCD_Bytes) from MFPS as input. When a PCD Major Frame sync word is identified, the PBP performs a majority vote on the next three bytes to determine the PCD information word. The PCD information word (PCD_Info_Word) is used to build the PCD Minor Frames in the PCD Frames Assembly function.

This function computes a failed PCD votes count (Failed_PCD_Votes)and outputs it to the PCD accounting file (PCD_Acct).

3.4.3.2 PCD Frames Assembly

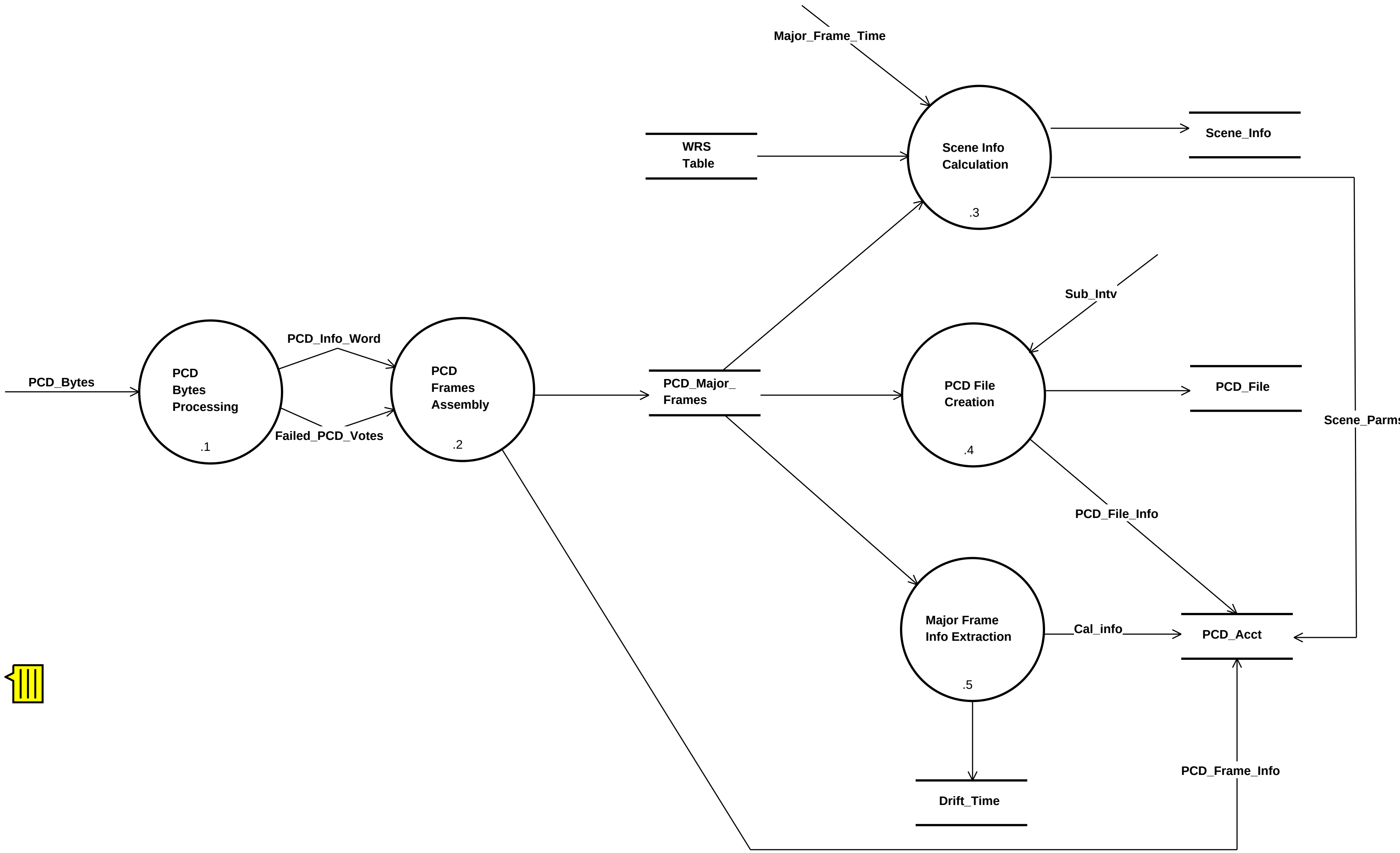
The PCD Frames Assembly function accepts PCD information words (PCD_Info_Word) from the PCD Bytes Processing function. The PCD information words are used to build the PCD Minor Frames. Each PCD Minor Frame consists of 128 PCD information words. The PCD Minor Frames are used to build the PCD Major Frames (PCD_Major_Frames). PCD Major Frames consist of 128 PCD Minor Frames.

The PCD major and minor frame information (PCD_Frame_Info) is generated in the PCD Frames Assembly function. The PCD major and minor frame information consists of the number of failed PCD votes (Failed_PCD_Votes), the number of PCD minor frames with sync errors, the number of PCD filled minor frames, and the number of PCD filled major frames. The PCD major and minor frame information (PCD_Frame_Info) is included in the PCD accounting file (PCD_Acct).

3.4.3.3 PCD File Creation

The PCD File Creation function accepts PCD Major Frames (PCD_Major_Frames) from the PCD Frames Assembly function. The PCD Major Frames are grouped into PCD cycles. Each PCD cycle consists of four PCD major frames. The PCD cycle is then used to build the PCD File (PCD_File). This function maintains the PCD file on a sub-interval basis.

1.4;14
PCD Processing



This function generates the PCD file information (PCD_File_Info), on a sub-interval basis, to be included into the PCD accounting file (PCD_Acct).

3.4.3.4 Scene Info Calculation

The Scene Info Calculation function accepts PCD_Major_Frames from the PCD Frames Assembly function. The ephemeris and the attitude information are extracted from the PCD_Major_Frames to calculate the scene identification. In addition, this function requires the WRS table (WRS_table) and the ETM+ major frame time (Major_Frame_Time) to identify all WRS scenes in a sub-interval. This function also calculates the Sun azimuth and elevation and includes these in its scene information (Scene_info) and scene parameters (Scene_Parm) outputs. The scene information (Scene_info) is used by the IDPS and the scene parameters (Scene_Parm) are incorporated into the PCD accounting file (PCD_Acct) for use by the MACS.

3.4.3.5 Major Frame Info Extraction

The Major Frame Info Extraction function accepts PCD_Major_Frames from the PCD Frame Assembly function. The Serial Word P of each PCD major frame is extracted and used to determine the calibration door status for the PCD major frame. The calibration door information (Cal_Info) is included in the PCD accounting file (PCD_Acct). The drift time (Drift_Time) is also extracted from the PCD Major Frame. The drift time is used by the IDPS on a sub-interval basis.

3.4.4 Data

This section describes the data flows and data stores appearing in Figures 3-7 and 3-8.

Cal_Info: A structure that contains the calibration door status for each PCD major frame. The Cal_Info is generated on a sub-interval basis.

Drift_Time: Time of last clock update and drift rate extracted from PCD.

Failed_PCD_Votes: The number of failed attempts to perform a successful bit-wise majority rule of three consecutive PCD_Info_Word. The majority vote is performed using the three consecutive words that follow the sync byte of the byte stream extracted from the PCD/Status section of the VCDU.

Major_Frame_Time: See MFPS.

PCD_Acct: A file that consists of the PCD_Frame_Info, Cal_Info, the PCD_File_Info, and the Scene_Parms. The PCD_Acct file is maintained on a sub-interval basis.

PCD_Bytes: See MFPS.

PCD_File: The PCD major frames received during a sub-interval on a full PCD cycle basis. A PCD cycle consists of four PCD major frames.

PCD_File_Info: The name of the PCD file. The PCD files are generated on a sub-interval basis.

PCD_Frame_Info: The statistics that are gathered from the processing of PCD bytes and the building of PCD major and minor frames.

PCD_Info_Word: An eight-bit word that contains telemetry information regarding the status of the spacecraft and its subsystems.

PCD_Major_Frames: Mission related telemetry that consists of attitude, ephemeris, jitter and other data used to correct the ETM+ imagery.

Scene_Info: The scene identification (latitude, longitude, PCD time of latitude and longitude, and major frame time for WRS scene center), Sun azimuth and elevation, and the parameters used to calculate these for each scene on a sub-interval basis.

Scene_Parms: Attitude, ephemeris, PCD time, major frame time, center and corner latitudes and longitudes, and Sun azimuth and elevation.

Sub_Intv: See MFPS.

WRS_Table: A global notation system that is used to identify any portion of the world by a path and row number.

3.4.5 Subsystem Hardware

An instance of the PCDS executes on the SGI host of each LPS string.

3.4.6 Subsystem Software

The PCDS software consists of custom application code only. The algorithm used to determine the WRS scene identification for previous Landsat missions is being investigated to determine reusability for the Landsat 7 mission. The reuse possibility and statistics on reuse levels will be included in the software design phase.

3.5 LPS Image Data Processing Subsystem (IDPS)

The IDPS performs browse image file generation and band file generation as well as Automatic Cloud Cover Assessment (ACCA). The IDPS accepts a specification of the band(s) to be used to generate browse image files from the operator via the MACS and also produces accounting information which is used by the MACS to generate metadata. The band files and browse files generated are stored for eventual transfer to the LP DAAC.

3.5.1 Requirements Allocation

Table 3-5 provides the IDPS requirements map. The complete mapping of LPS system requirements to subsystems is provided in Appendix A.

3.5.2 Interfaces

Figure 3-9 illustrates the IDPS's system context and external interfaces. The IDPS receives aligned band data (Aligned_Bands), status information (Status_Info), and sub-interval information (Sub_Intv) from MFPS, WRS scene identification, Sun azimuth, and elevation (Scene_Info), and drift time (Drift_Time) from the PCDS, and band parameters (Band_Parms) from the Management and Control Subsystem (MACS).

The IDPS outputs band (Band_File) and browse (Browse_File) data files to the LDTS and band, browse and ACCA accounting information (IDP_Acct) to the MACS. The IDPS also outputs the ACCA results (ACCA) to the MACS. Finally, the IDPS places the band specification (Band_Parms) from the MACS in a data store for later reference or update.

3.5.3 Functional Description

Figure 3-10 contains the IDPS's level 0 data flow diagram. The diagram shows the IDPS's primary functions. Those functions are described in the subsections below.

3.5.3.1 Browse File Generation

The Browse File Generation function is responsible for generating both browse files (Browse_File) and browse accounting information (Browse_Acct) on a sub-interval basis.

Table 3-5: IDPS Requirements Map

Number	Requirement Description
3.1.1	LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.
3.1.2	LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.
3.1.3	LPS shall provide the capability to receive, record and process 4 simultaneous wideband data inputs from the LGS, and deliver LPS output files.
3.1.5	LPS shall process wideband data to generate LPS output files on a received sub-interval basis.
3.1.10	The LPS shall provide an interactive intervention capability to detect and correct abnormal system conditions during LPS data capture and processing activities.
3.1.10.6	LPS shall provide the capability to test LPS functions and external interfaces.
3.1.10.7	LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.
3.1.10.8	LPS shall provide the capability to support end-to-end testing of LPS functions.
3.1.19	LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.
3.1.20	LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.
3.1.21	LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.
3.1.22	LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.
3.1.23	LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.
3.3.2.24	LPS shall provide the capability to process wideband data to level 0R.
3.3.2.25	LPS shall provide the capability to generate the following correlated Level 0R file(s) on a received sub-interval basis...
3.3.2.27	LPS shall calculate the spacecraft drift time based on information available in the PCD and append that time to the Level 0R data file.
3.3.2.28	LPS shall append the status data contained in the VCDU mission data zone, as specified in Applicable Document 3, to Level 0R files(s) on a major frame basis.

Table 3-5: IDPS Requirements Map

Number	Requirement Description
3.3.3.2	(Monochrome browse requirement is deleted)
3.3.3.3	LPS shall provide the capability to generate multiband browse data from three predetermined bands of the ETM+ Format 1 scene data.
3.3.3.4	LPS shall include the following information on the browse data generated for each sub-interval...
3.3.3.5	LPS shall provide the capability to generate browse data using a predetermined reduction factor.
3.3.4.8	LPS shall provide the capability to perform automatic cloud cover assessment (ACCA) for WRS scenes.
3.3.4.9	LPS shall provide the capability to perform ACCA on both scene quadrant and full scene basis.
3.3.4.10	LPS shall use predefined comparison values in performing ACCA.
3.3.6.1	LPS shall provide the capability to generate and modify LPS set-up tables from operator inputs.
3.3.6.9	LPS shall provide the capability to selectively enable and/or disable each of the following functions: … b. Generate Level 0R Files …
4.1.3	LPS shall provide the capability to receive and process the equivalent of 250 Landsat 7 ETM+ scenes of wideband data per day (approximately 100 GB per day).
4.1.4	LPS shall provide the capability to receive and process the daily volume of wideband data within 16 hours of its receipt at LPS.
4.1.5	LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data ...
4.1.6	LPS shall provide the capability to process received wideband data at an average aggregate rate of 12 megabits per second (Mbps) (Includes 10% of overhead due to reprocessing).
4.1.8	LPS shall introduce no more than one bit error in 10^9 bits.
4.1.9	LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a BER of one bit error in 10^5 bits, without loss of level zero processed data and without retransmission.
4.3.4	The LPS shall provide the capability to generate browse data with a reduction factor of 16 or better.

Table 3-5: IDPS Requirements Map

Number	Requirement Description
4.4.2	LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.
4.4.3	Any LPS time to restore shall not exceed twice the required MTTRes in 99 percent of failure occurrences.

The task first determines the bands (Aligned_Bands) to use for browse generation by retrieving the band parameter (Band_Parms) from a data store. The task then uses a hybrid wavelet/subsampling algorithm to produce lower resolution, reduced size scenes of the full-size scene data contained in a Level 0R instrument data file.

These browse image files are used by the end users for determining the geographical coverage, the spatial relationships between ground area coverage and cloud coverage, information content and image quality of the Level 0R data.

The algorithm uses a reduction factor of 16 or better to generate the browse files, and may also annotate the files in order to identify the browsed WRS scene image.

3.5.3.2 Band File Generation

The Band File Generation function is responsible for generating a band file (Band_File) which is based on a sub-interval (Sub_Intv) and contains aligned band information (Aligned_Bands). There will be one file per band.

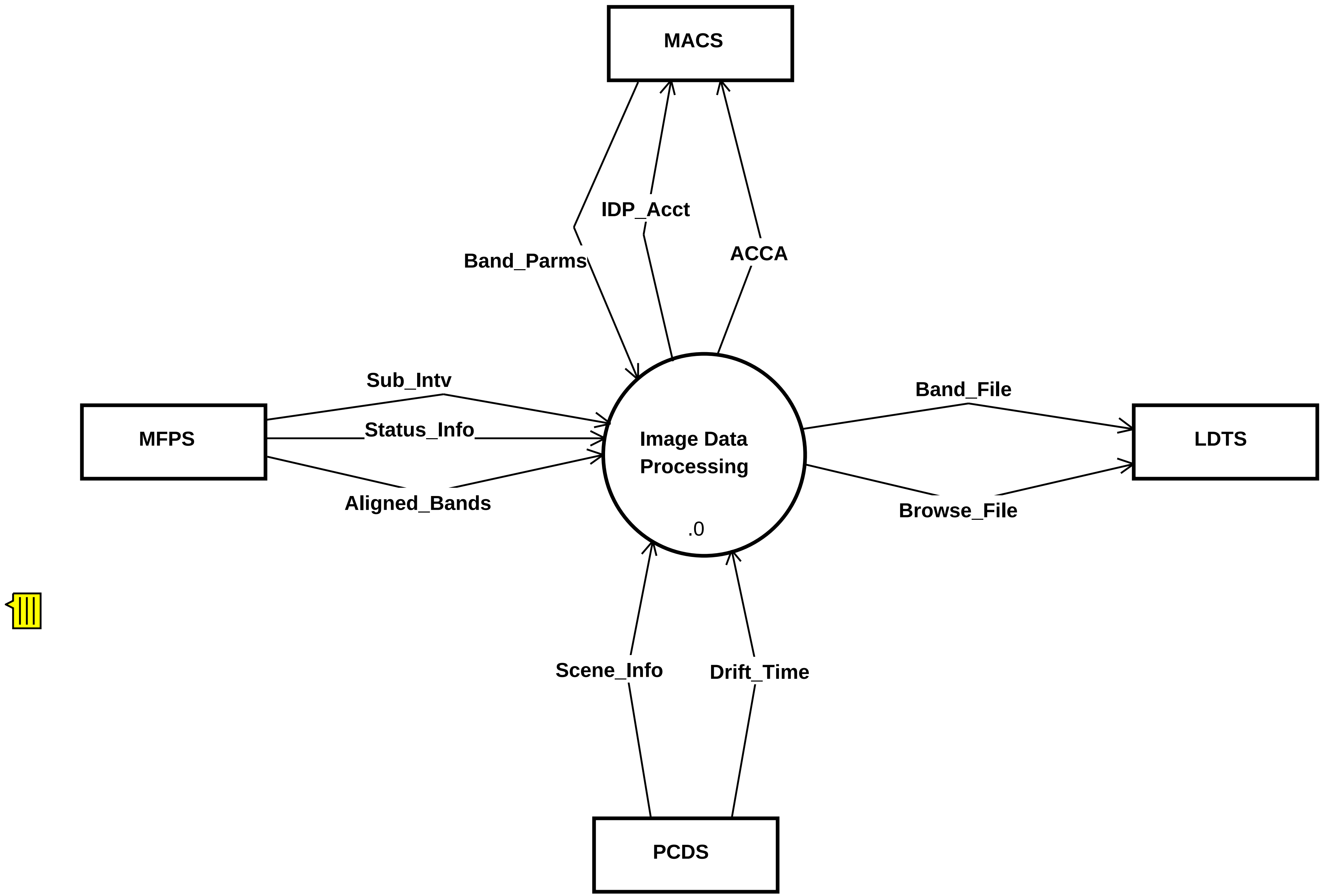
This task will use the drift time (Drift_Time) from the PCDS to adjust the Landsat clock time and will also provide accounting information (Band_Acct) to the IDP_Acct file such as the band file name, size and time tag.

This task will also extract system information from the status information (Status_Info) received from the MFPS in order to include this in the band files (Band_File).

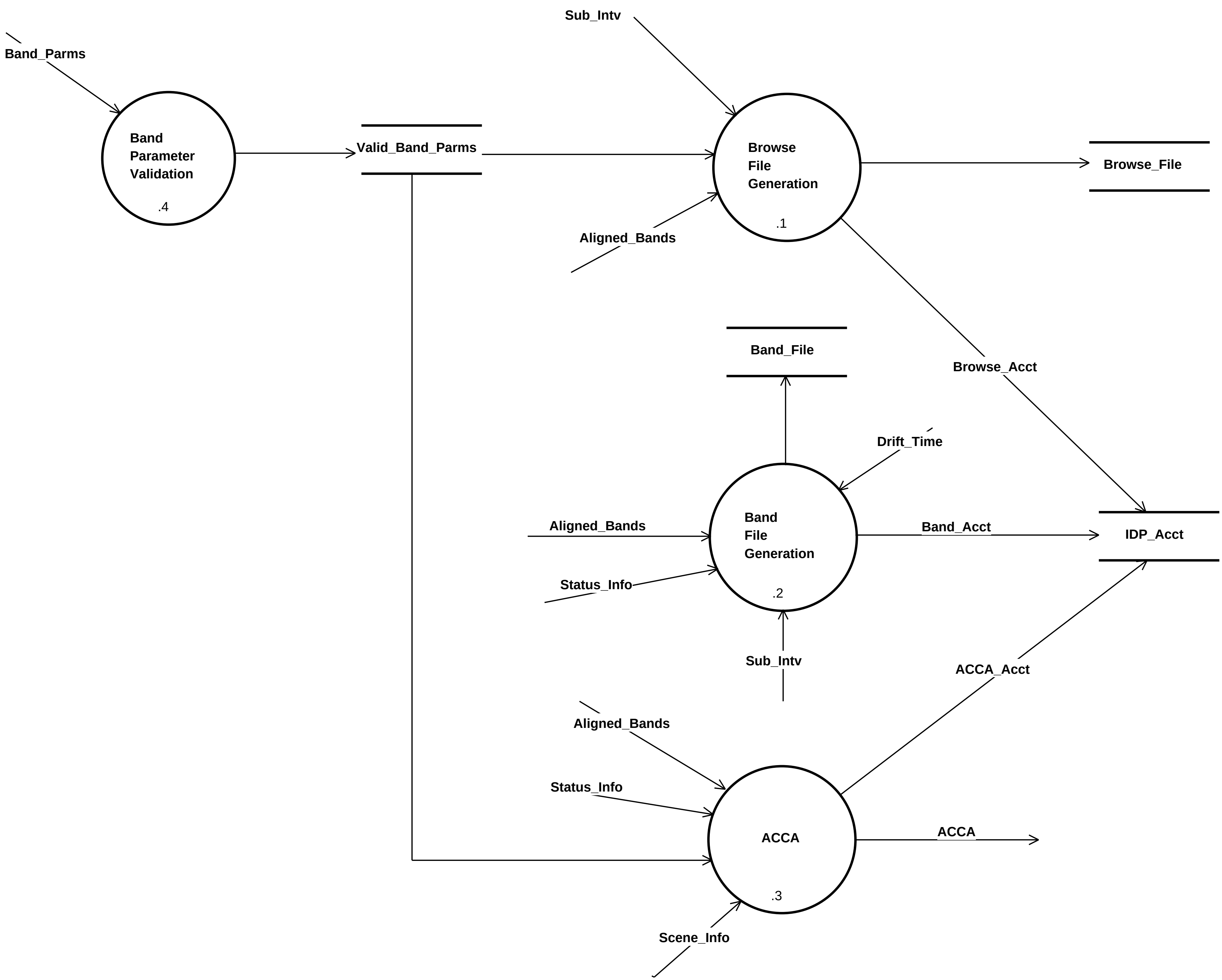
3.5.3.3 Automatic Cloud Cover Assessment (ACCA)

The ACCA function is responsible for determining cloud coverage on a scene quadrant and full scene basis (Scene_Info). An algorithm will be used to determine if clouds are present. This algorithm is then applied to the data on a predefined subsample basis.

1.51;4
IDPS_Context_Diagram



1.5;13
Image Data Processing



Performing the ACCA on scene data (Aligned_Bands) provides the scores for cloud coverage on a per quadrant basis (ACCA) and a score for cloud coverage on a WRS scene basis. This information (ACCA_Acct) is stored as part of the LPS Level 0R metadata (IDP_Acct).

ACCA will extract the band gain from the status information (Status_Info) received from the MFPS. The band gain is used in the ACCA algorithm. This task will also retrieve the band parameter from the Band_Parms data store in order to identify which band to process.

Control: The ACCA process is dependent on the completion of the scene identification, which occurs within the PCD Processing subsystem.

3.5.3.4 Band Parameter Validation

The Band Parameter Processing function accepts band parameters (Band_Parms) from the MACS, converts them to the subsystem's internal format (if necessary), validates them, and stores the validated parameters in the Valid_Band_Parms data store. The band parameter specifies which band is to be used when performing ACCA or Browse File Generation. It is generated by the operator and can be changed at any time. Changes made prior to the start of Browse File Generation or ACCA for a particular sub-interval will take effect for that sub-interval.

3.5.4 Data

ACCA: The cloud coverage information consists of five scores: one score indicating the amount of cloud coverage per quadrant, and an aggregate score indicating the amount of cloud coverage for an entire WRS scene. These scores are sent to the MACS to be included into the LPS Level 0R metadata.

ACCA_Acct: A file containing quality information relating to the cloud coverage assessment process. This information is stored in the IDP_Acct file.

Aligned_Bands: See MFPS.

Band_Acct: A file containing the aligned band data filename, the time tag of the file, the size of the file, and quality determined by the band fill data. This information is stored in the IDP_Acct file.

Band_File: A set of files of deinterleaved data with one file per band. This information is used to generate Level 0R files.

Band_Parms: A parameter indicating which bands to process for both browse and ACCA. This directive originates with the operator. Changes will take effect if they are made prior to the start of browse and ACCA processing.

Browse_Acct: A file containing the browse image filename, the time tag of the file, the size of the file, and quality information relating to the browse image. This information is stored in the IDP_Acct file.

Browse_File: A reduced data volume, lower resolution image file of the full size scene data contained in a Level 0R instrument data file. This file is generated by the Browse task.

Drift_Time: See PCDS.

IDP_Acct: The three functions update the IDP_Acct file with Browse_Acct, Band_Acct and ACCA_Acct information. This IDP_Acct file is then used by MACS to generate the metadata file.

Scene_Info: See PCDS.

Status_Info: See MFPS.

Sub_Intv: See MFPS.

Valid_Band_Parms: Band_Parms that have been validated and stored for use in processing.

3.5.5 Subsystem Hardware

An instance of the IDPS executes on the SGI host of each LPS string.

3.5.6 Subsystem Software

The IDPS subsystem may be able to reuse some of the software written for the browse and ACCA prototypes if the same algorithms are used for these tasks. The reuse possibility and statistics on reuse levels will be included in the software design phase.

3.6 Management and Control Subsystem (MACS)

The Management and Control Subsystem (MACS) is responsible for the system-level control and monitoring of LPS devices and processes, providing the interface medium between the LPS system and the operator. It is also responsible for generating LPS metadata files and maintaining the metadata accounting tables and for initiating data capture automatically according to the contact schedule. The following sections describe the system requirements allocated to MACS, the interfaces to other subsystems, the

MACS's primary functions, and the data, hardware and software used in MACS.

3.6.1 Requirements Allocation

Table 3-6 provides the MACS requirements map. The complete mapping of LPS system requirements to subsystems is provided in Appendix A.

3.6.2 Interfaces

Figure 3-11 illustrates the MACS's system context and external interfaces. It receives contact schedules in hard copy form from the LGS. The LPS operator uses the contact schedules to control LPS raw data capture. The MACS receives reprocessing requests (Reprocess_Notif) via personnel contact and sensor alignment information (Sensor_Alignment_Info) in hard copy form from the IAS. Reprocessing requests cause the LPS operator to initiate reprocessing for the requested raw wideband data set. The LPS operator enters the sensor alignment information into the LPS system, where it is used by the MFPS to perform band alignment.

The MACS receives restage status and data receive summary reports (RDC_Sum) from the RDCS. It receives return link quality and accounting reports from the RDPS (RDP_Sum). It receives sub-interval time ranges (Sub_Intv) and major frame quality and accounting information (MFP_Acct) from the MFPS. It receives cloud cover assessments (ACCA) as well as browse file, band file, and cloud cover assessment quality and accounting information (IPD_Acct) from the IDPS. It receives WRS scene information, sun azimuth and elevation, scene parameters, quality, and accounting information as well as PCD processing quality and accounting information from the PCDS. It receives a data transfer summary report (Transfer_Sum) from the LDTS.

The MACS outputs data receive summaries and return link quality and accounting reports (Return_Link_QA) to the MOC.

The MACS outputs directives that start and stop data capture, that request data receive summaries, and that request that data be restaged (RDC_Directives) to the RDCS. It outputs CCSDS processing parameters updates (CCSDS_Parms) to the RDPS. It outputs directives specifying a raw wideband data set to be processed or for which a return link quality and accounting report is to be generated (RDP_Directives) to the RDPS. It outputs the sensor alignment information received from the IAS (entered into the system by the operator) to the MFPS. It outputs a specification of the band(s) to be used for browse file generation (Band_Parms) to the IDPS. It outputs a metadata file for each processed sub-interval (Metadata_File) as

Table 3-6: MACS Requirements Map (1 of 3)

Number	Requirement Description
3.1.1	LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.
3.1.2	LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.
3.1.3	LPS shall provide the capability to receive, record and process 4 simultaneous wideband data inputs from the LGS, and deliver LPS output files.
3.1.5	LPS shall process wideband data to generate LPS output files on a received sub-interval basis.
3.1.8	LPS shall provide the capability to reprocess wideband data.
3.1.10	The LPS shall provide an interactive intervention capability to detect and correct abnormal system conditions during LPS data capture and processing activities.
3.1.10.1	LPS shall provide a system start-up capability.
3.1.10.2	LPS shall provide a system shut-down capability.
3.1.10.3	LPS shall provide the capability to generate and report LPS error messages
3.1.10.4	LPS shall provide the capability to isolate system faults.
3.1.10.5	LPS shall provide the capability to recover from system faults.
3.1.10.6	LPS shall provide the capability to test LPS functions and external interfaces.
3.1.10.7	LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.
3.1.10.8	LPS shall provide the capability to support end-to-end testing of LPS functions.
3.1.11	LPS shall provide the capability to control LPS operations.
3.1.12	LPS shall provide the capability to monitor LPS operations.
3.1.14	LPS shall provide the capability to configure system resources to support LPS operations (with normal or fall-back configurations).
3.1.19	LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.
3.1.20	LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.
3.1.21	LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.

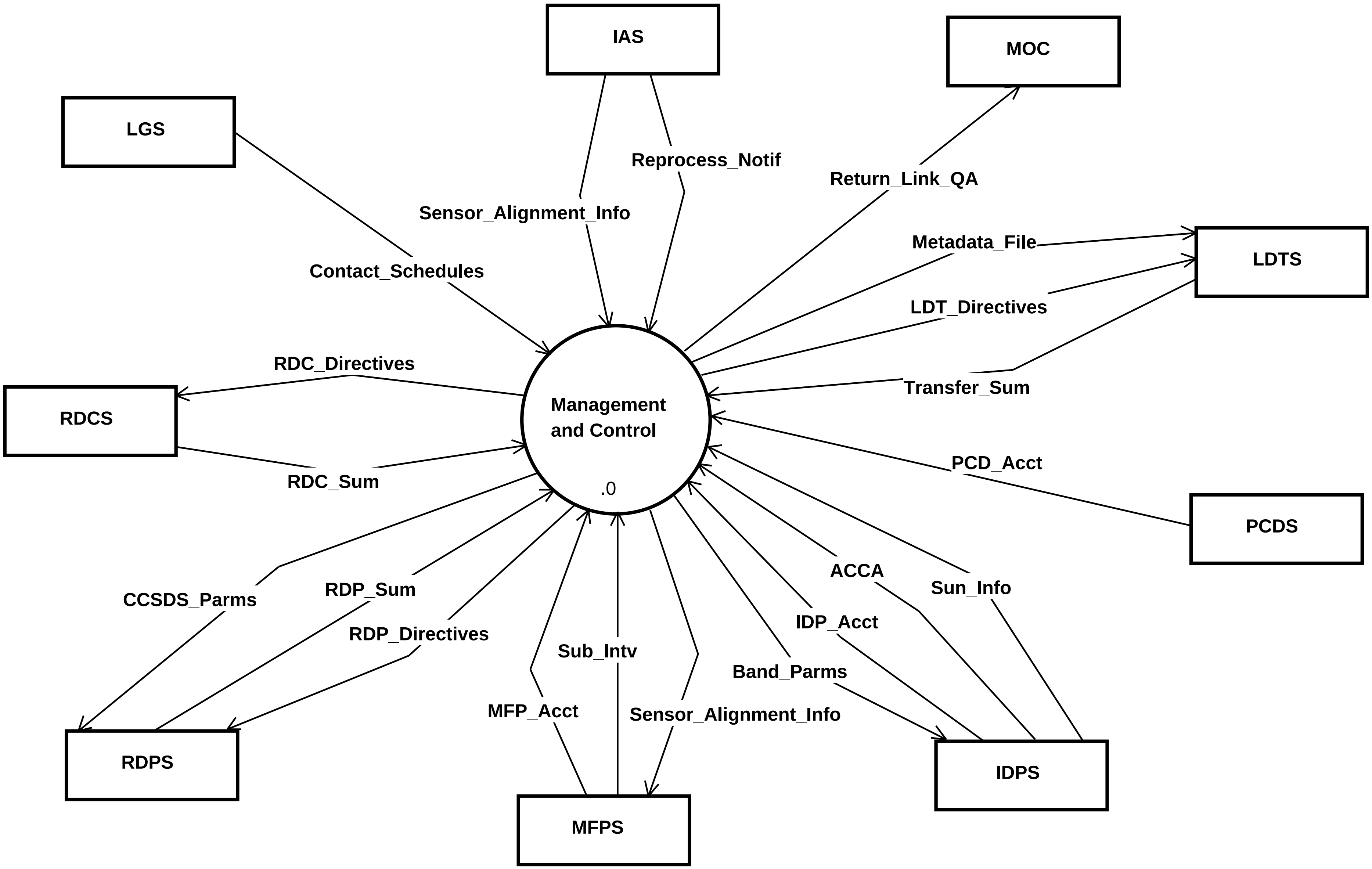
Table 3-6: MACS Requirements Map (2 of 3)

Number	Requirement Description
3.1.22	LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.
3.1.23	LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.
3.2.3	LPS shall interface with the Mission Operations Center (MOC)
3.2.4	LPS shall interface with the Image Assessment System (IAS)
3.3.1.7	LPS shall provide the capability to record return link wideband data to removable storage media, on a Landsat 7 contact period basis.
3.3.1.8	LPS shall provide the capability to save removable storage media recorded with return link wideband data.
3.3.1.9	LPS shall provide the capability to retrieve return link wideband data from removable storage media.
3.3.1.10.1	LPS shall forward, via voice or FAX interface, the wideband data receive summary to the MOC within 5 minutes of data receipt at the LPS.
3.3.1.11	LPS shall coordinate the receipt of return link wideband data with LGS.
3.3.1.13	LPS shall coordinate resolution of all data transfer problems with LGS.
3.3.4.11	LPS shall generate Level 0R metadata (ancillary data) file(s) on a sub-interval basis.
3.3.4.12	LPS shall generate and include the following Level 0R metadata information in each Level 0R metadata file...
3.3.5.5	LPS shall provide a manual over-ride and protected capability to delete all LPS files on a specific contact period basis.
3.3.5.6	LPS shall provide a manual over-ride and protected capability to retain all LPS files on-line on a specific contact period basis.
3.3.6.1	LPS shall provide the capability to generate and modify LPS set-up tables from operator inputs.
3.3.6.2	LPS shall provide the capability to collect and report Landsat 7 return link quality and accounting data for each wideband data input on a Landsat 7 contact period basis.
3.3.6.3	LPS shall provide the capability to collect and report Level 0R quality and accounting data for each wideband data input on a sub-interval basis.
3.3.6.4	LPS shall display quality and accounting data upon operator request.
3.3.6.4.1	LPS shall print quality and accounting data upon operator request.
3.3.6.5	LPS shall provide the capability to display LPS file(s) transfer summary upon operator request.

Table 3-6: MACS Requirements Map (3 of 3)

Number	Requirement Description
3.3.6.5.1	LPS shall provide the capability to print LPS file(s) transfer summary upon operator request.
3.3.6.6	The LPS shall allow the operator to select thresholds for results and errors reported by the LPS.
3.3.6.7	LPS shall automatically generate messages and alarms to alert the operator of LPS results and errors exceeding selected thresholds.
3.3.6.8	LPS shall provide the capability to manually override the LPS automated functions.
3.3.6.9	LPS shall provide the capability to selectively enable and/or disable each of the following functions: a. Receive Wideband Data b. Generate Level 0R Files c. Transfer LPS Files
4.1.3	LPS shall provide the capability to receive and process the equivalent of 250 Landsat 7 ETM+ scenes of wideband data per day (approximately 100 GB per day).
4.1.4	LPS shall provide the capability to receive and process the daily volume of wideband data within 16 hours of its receipt at LPS.
4.1.5	LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data ...
4.1.6	LPS shall provide the capability to process received wideband data at an average aggregate rate of 12 megabits per second (Mbps) (Includes 10% of overhead due to reprocessing).
4.1.8	LPS shall introduce no more than one bit error in 10^9 bits.
4.1.9	LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a BER of one bit error in 10^5 bits, without loss of level zero processed data and without retransmission.
4.4.1	LPS shall provide an Operational Availability (A_o) of 0.96 or better for all processing functions.
4.4.2	LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.
4.4.3	Any LPS time to restore shall not exceed twice the required MTTRes in 99 percent of failure occurrences.

1.61;4
MACS_Context_Diagram



well as directives overriding the automatic deletion or retention of output files (LDT_Directives) to the LDTS.

3.6.3 Functional Description

Figure 3-12 contains the MACS's level 0 data flow diagram. The diagram shows the MACS's primary functions. Those functions are described in the subsections below.

3.6.3.1 Directive Generation

This function provides the LPS operator the capability to enter the system intervention directives, to update the LPS processing configuration information, and to query the LPS operational readiness status or summary reports. Some of the directives are driven by the LGS and the IAS after receiving the contact schedules or sensor alignment information in hard copy form.

3.6.3.2 Directive Processing

This function processes the information queries, LPS processing configuration updates, and processing intervention directives upon receipt of the directives from the operator or system administration personnel. The processing intervention directives are then forwarded to the target subsystems for further processing. Examples of these directives are as follows:

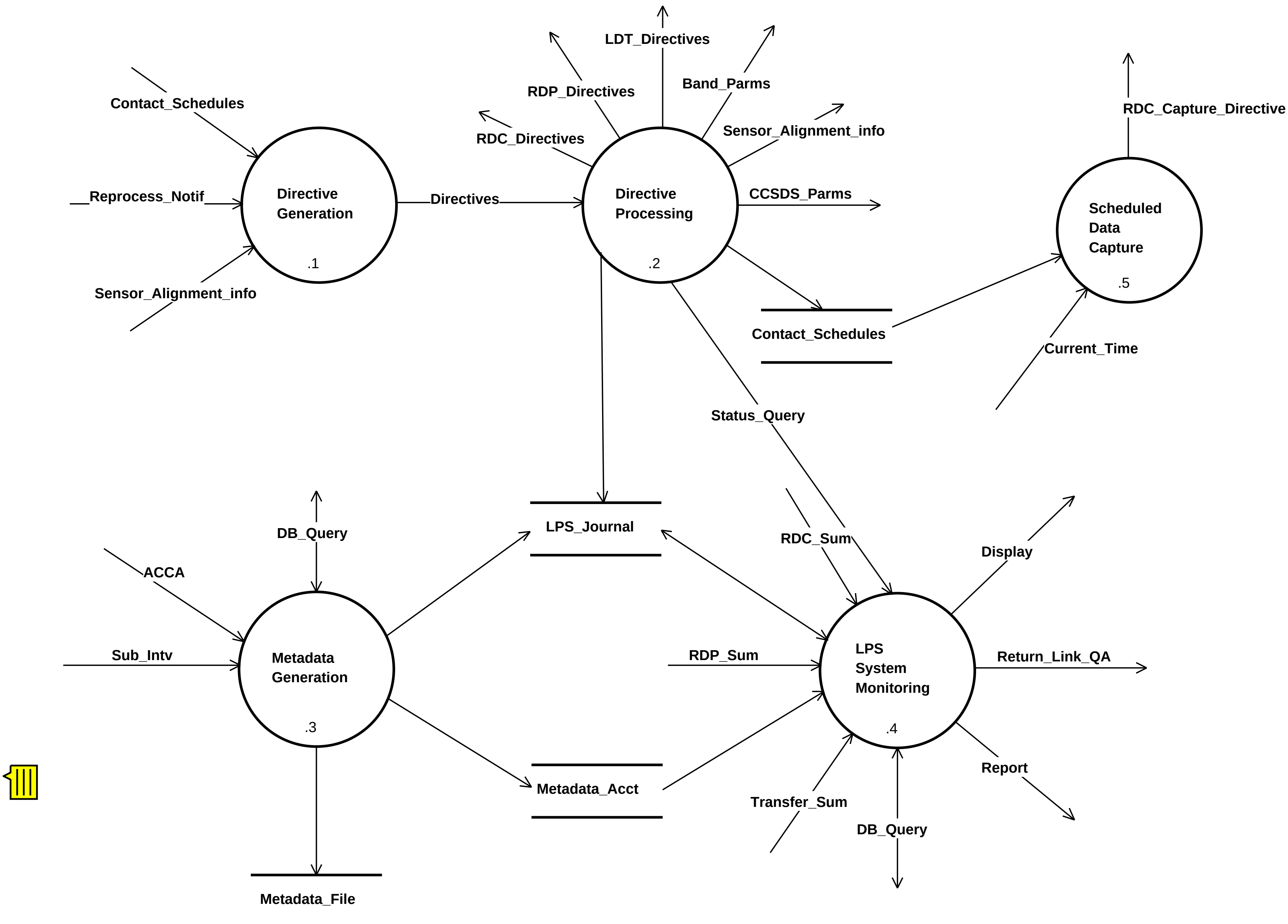
- Reprocess directives
- Raw data capture directives
- Raw data processing directives
- LPS file management directives

The LPS processing configuration updates are forwarded to the target subsystems for updating the LPS processing configuration tables in the database. Examples of these updates are as follows:

- Sensor alignment information table update

- CCSDS processing parameters table update

1.6;19
Management and Control



- Band parameters table update

The information queries are forwarded to the LPS System Monitoring function for status display or report.

3.6.3.3 Metadata Generation

The Metadata Generation function creates the Metadata files upon receipt of the sub-interval information from the MFPS. Upon completion of current sub-interval LPS files, it first retrieves the quality and accounting information belonging to current sub-interval from the subsystems and constructs the metadata file and the metadata accounting. It outputs the metadata file to the LTDS.

3.6.3.4 LPS System Monitoring

The LPS System Monitoring function retrieves LPS devices and processing status information to detect any device/processing anomaly and alert the operator. It serves the operator for displaying the LPS status information or generating the LPS status report. It provides the return link quality and accounting information to the MOC upon request.

3.6.3.5 Scheduled Data Capture

The Scheduled Data Capture function controls automatic data capture driven by the contact schedule contained in the Contacta_Schedules data store. This function accepts the Current_Time from the operating system. The function issues a start capture directive to the RDCS when the current time (minus a period of time sufficient for RDCS capture set up) is equal to a scheduled contact start time and issues a stop capture directive to the RDCS when the current time is equal to the contact stop time.

3.6.4 Data

ACCA: See IDPS.

Contact_Schedules: The daily LPS contact schedules provided by LGS in hard copy form**.**

Current_Time: The operating system time.

DB_Query: The MACS issues the quality and accounting information queries to the subsystems for creating the LPS metadata files, displaying LPS processing status, or generating LPS processing status report.

Directives: The LPS user interface provides the operator and system administration personnel with the ability of entering directives to query system status information, update the LPS processing configuration tables, and intervene the LPS processing:

RDC_Directives: Directives sent to the RDCS to start or stop data capture, to request that a raw wideband data set be restaged for reprocessing, or to request a data receive summary report for a captured raw wideband data set.

RDP_Directives: Directives sent to the RDPS to specify a raw wideband data set to be processed or to request a return link quality and accounting report for a processed raw wideband data set.

LDT_Directives: Directives sent to the LDTS for controlling LPS file management. They include Delete-File-Directive, Retain-File-Directive.

Sensor_Alignment_Info: See MFPS.

CCSDS_Parms: See RDPS.

Band_Parms: See IDPS.

LPS_Journal: The MACS receives and stores the device and processing event log during LPS operation. This information provides the operator and system administration personnel with the capability to monitor LPS operation and identify the system faults.

Metadata: The MACS summaries the quality and accounting information on a sub-interval basis. The file contains the overall sub-interval quality and accounting information, the input data quality and accounting information, and the quality and accounting information for individual WRS scene.

Metadata Accounting: The metadata accounting features information needed for the operator to qualify the metadata file. It may contain the following information:

- Subinterval identifier
- Process time stamp
- Metadata file generation summary

RDC_Sum: See RDCS.

RDP_Sum: See RDPS.

Reprocess_Notif: A reprocessing request received through personnel contact from the IAS.

Return_Link_QA: Data receive summary reports and return link quality and accounting reports.

Status_Query: A request initiated by the operator to display LPS status or generate a LPS status report.

Sub_Intv: See MFPS.

Transfer_Sum: See LDTS.

3.6.5 Subsystem Hardware

An instance of the MACS executes on the SGI host of each LPS string. The LPS operator interface is via the Operations Interface HWCI terminals. Each terminal provides concurrent access to all LPS strings.

3.6.6 Subsystem Software

POSIX Compliant Software - The Management and Control Subsystem contains a portion of custom code compliant with POSIX standard.

Oracle DBMS SWCI - The storage of and access to LPS metadata quality and accounting information and LPS system journal are supported by the Oracle DBMS SWCI.

Graphic User Interface (GUI) - The window/mouse-based user interface of MACS is implemented through custom code and support from a commercial GUI.

3.7 LPS Data Transfer Subsystem (LDTS)

The LPS Data Transfer Subsystem (LDTS) is responsible for notifying the LP DAAC about the availability of LPS files on a contact basis. The LPS files include Band, Calibration, Mirror Scan Correction, PCD, Browse, and Metadata files. Upon receipt of a Data Availability Notification (DAN), the LP DAAC transfers the available files from the LPS output data store to its own storage. After transfer by the LP DAAC, the LDTS receives and processes a Data Transfer Acknowledgment (DTA) from the LP DAAC describing the status of file transfer. The LDTS uses the received DTA and operator's over-ride directives, if any, to manage the LPS files to ensure sufficient disk space for the LPS output data store. The LDTS generates a file transfer summary containing the statistic information about transmitted and retained LPS files and the space usage of the LPS output data store on a daily basis.

3.7.1 Requirements Allocation

Table 3-7 provides the LDTS requirements map. The complete mapping of LPS system requirements to subsystems is provided in Appendix A.

3.7.2 Interfaces

Figure 3-13 illustrates the LDTS's system context and external interfaces. The LDTS receives Calibration (Cal_File) and Mirror Scan Correction (MSCD_File) files from the Major Frame Processing Subsystem, Bands (Band_File) and Browse files (Browse_File) from the IDPS, a PCD file (PCD_File) from the PCD Processing Subsystem, and a Metadata file (Metadata_File) from the MACS on a sub-interval basis. The LDTS also accepts over-ride directives (LDT_Directives) from the MACS.

The LDTS generates and sends a DAN to the LP DAAC. The LDTS supports the transfer of LPS files by the LP DAAC. The LDTS receives a DTA from the LP DAAC. The LDTS provides a file transfer summary (Transfer_Sum) to the MACS.

3.7.3 Functional Description

Figure 3-14 contains the LDTS's level 0 data flow diagram. The diagram shows the LDTS's primary functions. Those functions are described in the subsections below.

3.7.3.1 File Management

The File Management function accepts Calibration (Cal_File) and Mirror Scan Correction (MSCD_File) files from the MACS, Bands (Band_File) and Browse (Browse_File) files from the IDPS, a PCD file (PCD_File) from the PCDS, and a Metadata file (Metadata_File) from the MACS on a sub-interval basis. When all data files in a contact are available on the disk, it sends an annotated LPS file information (LPS_File_Info) to the DAN Generation function.

Table 3-7: LDTS Requirements Map (1 of 2)

Number	Requirement Description
3.1.1	LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.
3.1.2	LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.
3.1.10	The LPS shall provide an interactive intervention capability to detect and correct abnormal system conditions during LPS data capture and processing activities.
3.1.10.6	LPS shall provide the capability to test LPS functions and external interfaces.
3.1.10.7	LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.
3.1.10.8	LPS shall provide the capability to support end-to-end testing of LPS functions.
3.1.3	LPS shall provide the capability to receive, record and process 4 simultaneous wideband data inputs from the LGS, and deliver LPS output files.
3.1.19	LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.
3.1.20	LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.
3.1.21	LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.
3.1.22	LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.
3.1.23	LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.
3.2.2	LPS shall interface with the LP DAAC to coordinate the transfer of LPS output files to the LP DAAC ...
3.3.5.1	LPS shall notify LP DAAC on the availability of LPS files.
3.3.5.2	LPS shall coordinate the reporting of file transfer problems with the LP DAAC.
3.3.5.3	LPS shall provide the capability to receive notification from LP DAAC on the successful receipt of transferred LPS files.
3.3.5.4	LPS shall provide the capability to store LPS data files until confirmation of successful transfer is received from the LP DAAC.

Table 3-7: LDTS Requirements Map (2 of 2)

Number	Requirement Description
3.3.5.5	LPS shall provide a manual over-ride and protected capability to delete all LPS files on a specific contact period basis.
3.3.5.6	LPS shall provide a manual over-ride and protected capability to retain all LPS files on-line on a specific contact period basis.
3.3.5.7	LPS shall provide the capability to generate LPS file(s) transfer summary, including the following information, on a daily basis
3.3.6.8	LPS shall provide the capability to manually override the LPS automated functions.
3.3.6.9	LPS shall provide the capability to selectively enable and/or disable each of the following functions: … c. Transfer LPS Files
4.1.3	LPS shall provide the capability to receive and process the equivalent of 250 Landsat 7 ETM+ scenes of wideband data per day (approximately 100 GB per day).
4.1.4	LPS shall provide the capability to receive and process the daily volume of wideband data within 16 hours of its receipt at LPS.
4.1.5	LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data ...
4.1.6	LPS shall provide the capability to process received wideband data at an average aggregate rate of 12 megabits per second (Mbps) (Includes 10% of overhead due to reprocessing).
4.1.7	LPS shall provide a maximum of 8 hours of on-line storage for temporary retention of LPS files.
4.1.8	LPS shall introduce no more than one bit error in 10^9 bits.
4.1.9	LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a BER of one bit error in 10^5 bits, without loss of level zero processed data and without retransmission.
4.2.2	LPS-LP DAAC interface shall provide the capability to transfer the daily volume of LPS output files to LP DAAC at an average aggregate rate of 40 Mbps.
4.4.1	LPS shall provide an Operational Availability (A_o) of 0.96 or better for all processing functions.
4.4.2	LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.
4.4.3	Any LPS time to restore shall not exceed twice the required MTTRes in 99 percent of failure occurrences.

1.71;2
LDST_Context_Diagram

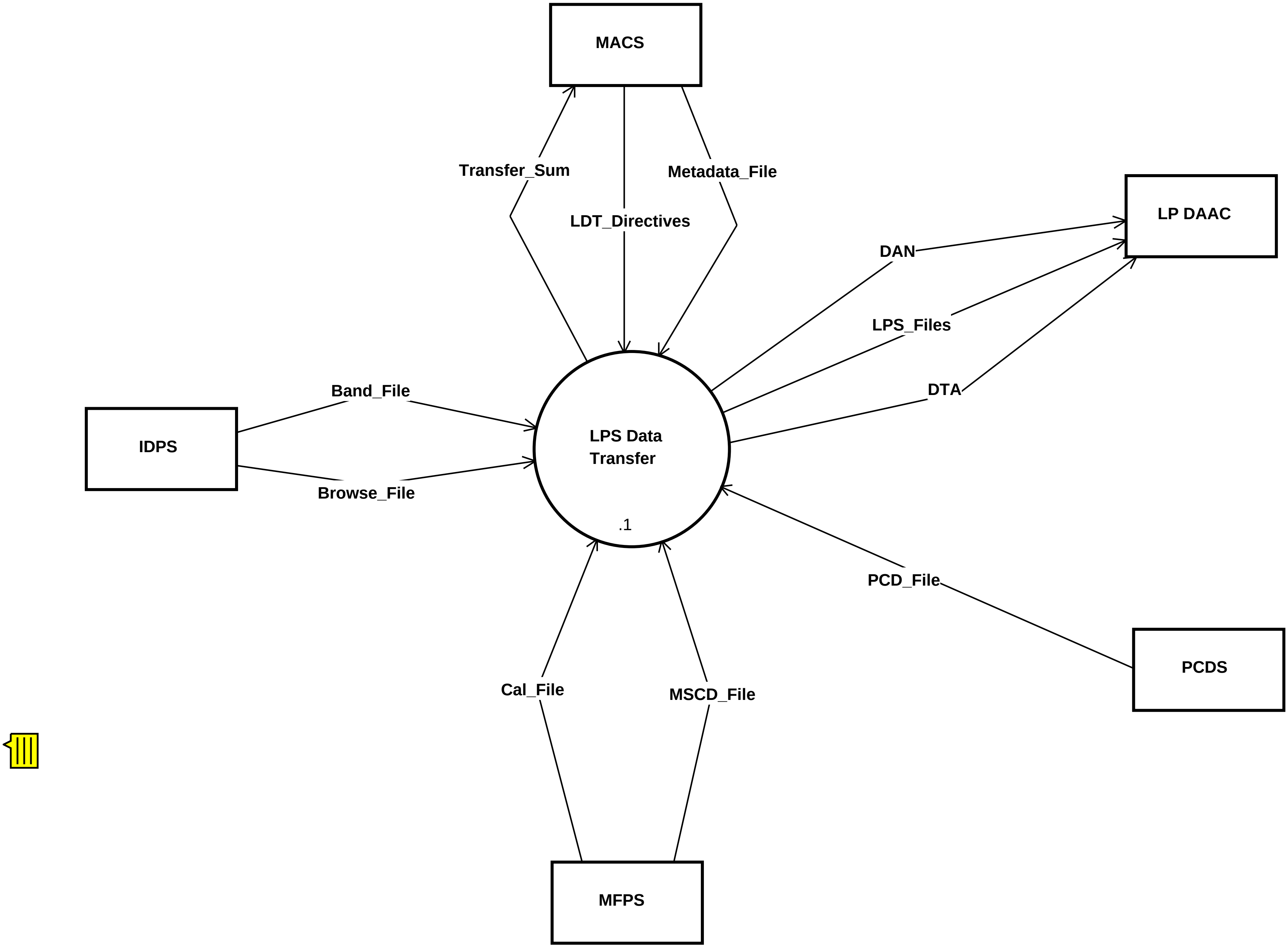


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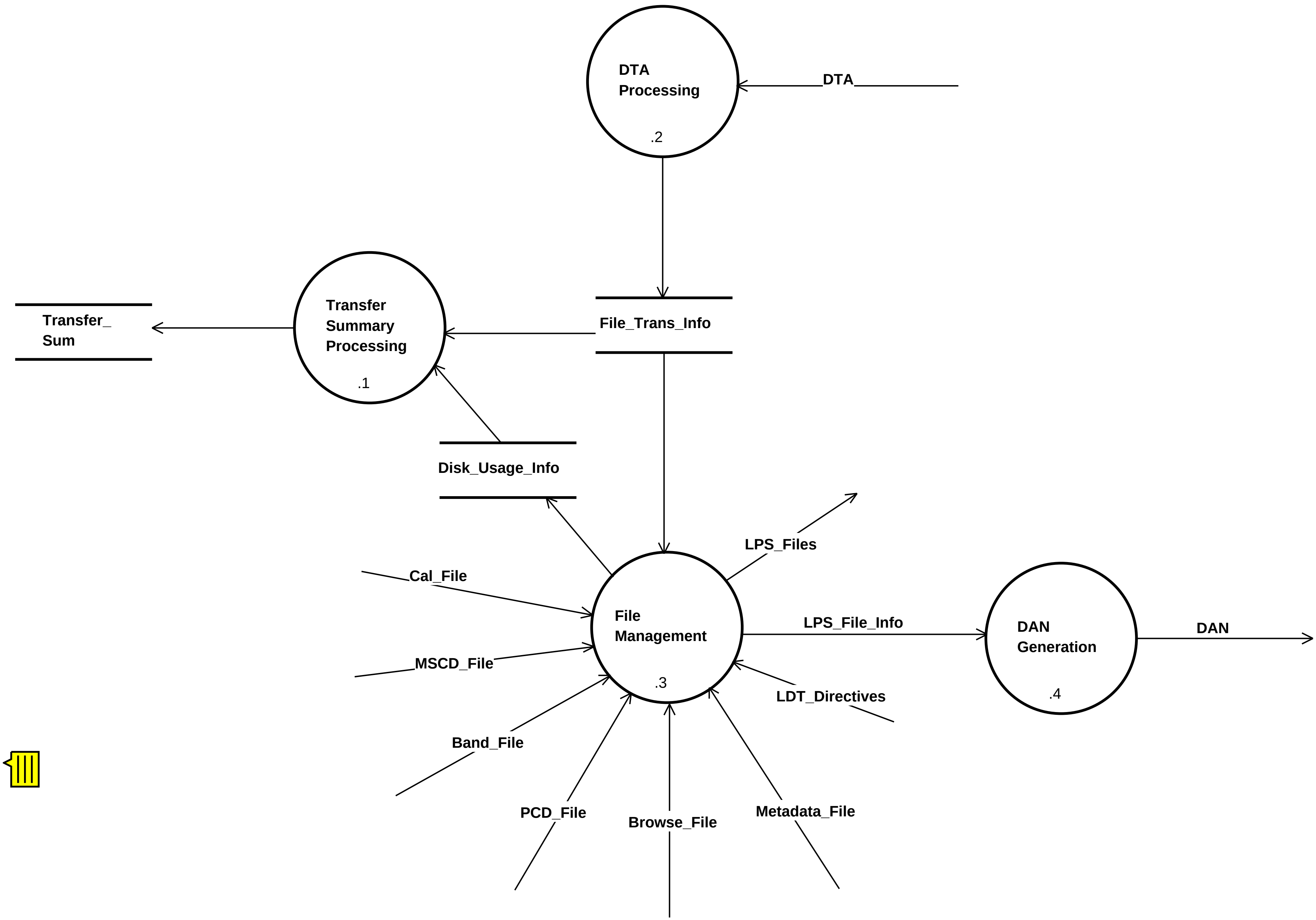
Figure 3-14: LDTS Level 0 Diagram

1.7;10
LPS Data Transfer



During the transfer of LPS files (LPS_Files) by the LP DAAC, the File Management function configures, if necessary, the LP DAAC communication interfaces to make LPS files available for transfer. The LP DAAC uses an application-level file transfer protocol such as File Transfer Protocol (FTP) or File Transfer Access and Management (FTAM). The File Management function accepts directives (LDP_Directives) from the MACS to manually over-ride the deletion and retention of all LPS files on a specific contact period basis. The File Management function receives file transfer information (File_Trans_Info) from the DTA Processing function to automatically maintain LPS files on the output data store.

3.7.3.2 DAN Generation

The DAN Generation function receives an annotated LPS file information (LPS_File_Info) from the File Management function. It informs the LP DAAC that data files are available to be transmitted by sending a DAN. The DAN Generation function selects the appropriate protocol and network address, establishes communications connection, transfers the DAN to the LP DAAC over the connection, and gracefully terminates the connection once communication is complete. If the connection can not be gracefully terminated, it aborts the connection.

3.7.3.3 DTA Processing

The DTA Processing function accepts a DTA from the LP DAAC. The DTA indicates whether or not the LPS files have been transmitted successfully. The DTA Processing function processes the DTA and updates the File_Trans_Info data store to indicate the transfer status of all LPS files referenced in the DTA. The File_Trans_Info data store is subsequently retrieved by the File Management function to automatically maintain LPS files on the output data store and the Transfer Summary Generation function to generate file transfer summaries.

3.7.3.7 Transfer Summary Processing

The Transfer Summary Processing function is responsible for generating a LPS file transfer summary (Transfer_Summary) on a daily basis. It retrieves the file transfer information generated by the DTA Processing function and the disk usage information from the File Management function. The Transfer Summary Processing function then outputs a file transfer summary to the MACS.

3.7.4 Data

Transfer_Summary: A summary containing the count of LPS files available, the count of LPS files retained on-line, the count of LPS files transmitted to the LP DAAC, and the usage and availability of data output store.

File_Transfer_Info: An aggregate accounting information including the name of LPS files and the status of their transmission to the LP DAAC.

LPS_Files: An aggregate of LPS data files including Band, Calibration, Mirror Scan Correction, PCD, Browse, and Metadata files.

Band_File: A file containing the image data from a single band in a single sub-interval.

Cal_File: A file containing all of the calibration data received on a major frame basis for a given sub-interval.

MSCD_File: A file containing the Scan Line data extracted from the two minor frames following the End of Line Code in each major frame of the sub-interval.

PCD_File: See PCDS.

Browse_File: A reduced data volume file of the band files of a sub-interval.

Metadata_File: A file containing information on the Level 0R data in a sub-interval.

DAN: A message from the LDTS indicating that a set of LPS files is available to be transmitted to the LP DAAC.

DTA: A message from the LP DAAC indicating the transmission status of LPS files.

LPS_File_Info: A list of available LPS file information on a contact period basis.

Disk_Usage_Info: A statistics information describing the usage of LPS output data store such as the size of used and available disk storage.

LDT_Directives: A list of operation directives which supports a manual over-ride from the operation personnel to retain or delete LPS files.

3.7.5 Subsystem Hardware

An instance of the LDTS executes on the Data Process HWCI of each LPS string. Each LPS string has an instance of the Data Transfer Store HWCI for LPS output data store and a FDDI LAN Controller Board HWC to support the LPS and LP DAAC communications. Several storage and network hardware technologies and communication protocols are being investigated to determine their suitability for LPS.

3.7.6 Subsystem Software

The LDTS software consists of both COTS packages for communications and networks and custom application code. In addition, Pacor II and Data Distribution Facility (DDF) software is being investigated to determine their reuse for LPS. The reuse possibility and statistics on reuse levels will be included in the software design phase.

4. System Support Software

This section specifies the system support software included in the LPS system design. Section 4.1, "LPS System Software," describes the operating system and device interface software specified for the LPS system design. Section 4.2, "COTS Software," specifies COTS application software specified for the LPS system design.

4.1 LPS System Software

LPS system software includes the IRIX operating system, Mizar MZ7772 board support software, and device interfaces for FDDI and RAID array devices. Section 4.1.1 describes the IRIX operating system. Section 4.1.2 describes Mizar MZ7772 board support software. Section 4.1.3 describes the FDDI device interface software. Section 4.1.4 describes the RAID array device interface software.

4.1.1 IRIX Operating System

IRIX is Silicon Graphics, Incorporated's (SGI's) version of the UNIX operating system. IRIX provides standard operating system services, utilities, device interfaces, run-time libraries, and user environments for both direct operational use and LPS application software support. The software architecture includes a version of the UNIX operating system both because UNIX provides an open system which enhances application portability and because a wide selection of UNIX-based commercial applications are available. The selection of IRIX was driven wholly by the selection of SGI servers as LPS processing hosts.

IRIX is a System V Release 4 (SVR4) based symmetric multiprocessor (SMP) multithreaded version of the UNIX operating system with BSD 4.X extensions. IRIX is compliant with POSIX 1004.1a, FIPS 151-1, SVID3, XPG3, and includes functionality compliant with POSIX 1004.4.

IRIX file system support includes disk striping. Unbundled support for Network File System and disk mirroring is available. Device support includes 8mm and 4mm tape device interfaces, MSDOS and Macintosh file system support on removable devices, Compact Disc support for ISO9660 and Rockridge format, and SVR4 MP DDI/DKI loadable driver support. Printing support is provided by lpd and lpsched. The IRIS Impressario™ printer management system is available as an unbundled product.

IRIX supports POSIX 1004.4 compliant asynchronous and direct I/O to Extent File System files. Interprocess Communications support includes SVR4 messages, semaphores, shared memory, FIFOs, and BSD sockets. IRIX user multiprocessor facilities include lightweight process parallelism, memory based synchronization, processor affinities, and parallelizing compilers for C and FORTRAN. IRIX supports the partitioning of multiple processors on a single system via processor set definition; applications can be restricted to executing on a particular set. Real-time support includes a preemptable kernel, non-degrading priorities, memory lockdown, high resolution timers, queued signals, and deadline scheduling. CPU time allocations within elapsed time segments can be specified. Processes can block waiting for CPU time allocation or yield allocated time. Unbundled support for distributed computing (NFS, NIS, RPC, automount, lockd, etc.) is available.

Networking support includes a Sockets/TCP/IP stack, FTP, remote login (rlogin and telnet), TLI, DLPI driver interface, Ethernet, SLIP, PPP, and HIPPI1. FDDI interface support is available as an unbundled product. SNA, DECnet™, LAT1, and OS1 Transport connectivity support are also available as unbundled products.

System administration support is provided by the Visual system administration toolchest and a graphic system monitor. Network management is supported with the SNMP based MIB II network manager. NetVisualyzer™ and Cabletron SPECTRUM Network Management System are available as unbundled products. Critical system problems are reported within the graphical user environment by a notifier that also suggests solutions and provides hyperlinks to on-line libraries and system tools. Backup/restore capabilities are provided by dump/restore, bru, cpio, tar, and Networker™ for IRIX. IRIX includes a tool that automates kernel tuning. Diagnostic tools include memory, CPU, and file system checks.

IRIX security features include auditing, shadow passwords, password aging, and expanded login options designed to support a C2 level of trust. A B12 version is available.

IRIX includes XPG3 compliant message catalogs and locale support for currency, date, etc., as well as wide character support. Country kits are available as unbundled products.

IRIX provides graphics support with OpenGL, X11R5, PFX, IRIX IM (a SGI enhanced version of OSF/Motif 1.2.3), and Display PostScript®.

IRIX usability features include the Indigo Magic™ user environment, Showcase™ presentation authoring tool, IRIS Inventor™, IRIS InSight™ SGML document reader, and on-line documents.

The LPS design includes use of the following IRIX operating system services:

- LPS operators use IRIX file system usage displays to verify sufficient disk space for upcoming data captures.
- X11R5/IRIX IM provides support for LPS control and monitor functions.
- LPS operators use IRIX process control capabilities to suspend/resume LPS data processing during data capture.
- LPS operators use the IRIX tape device interface to copy captured raw wide band data to the 60 day store's removable media.
- LPS operators use remote login capabilities to control multiple LPS strings from a single terminal/console.
- LPS system administrators use IRIX system logs and diagnostic tools to verify LPS string health and to isolate detected failures .
- LPS operators use IRIX shells to invoke LPS application processes.
- LPS operators use IRIX system time to schedule data capture and processing.
- The Land Processes Distributed Active Archive Center invokes the IRIX FTP daemon (ftpd) to transfer Level 0R files.

Maximum file size in the current version of IRIX (5.X) is 2 GBytes. This limitation is less than the expected size of LPS files. IRIX 6.0 will include 64-bit file addressing that eliminates this limitation and will support LPS output file size requirements. IRIX 6.0 is not currently available but is expected to be available soon enough to be included in the LPS system. Prototypes for both data capture and output file generation that are compatible with the IRIX 5.X file size limit are under development. These prototypes mitigate the risk that IRIX 6.0 will not be available for delivery as part of the LPS.

4.1.2 Mizar MZ7772 DSP Board Support

Mizar MZ7772 DSP Board Support Software includes libraries and utilities to download raw wide band data capture software to MZ7772 memory, to control its execution, and to determine its execution status. This software also includes utilities and diagnostics for troubleshooting the MZ7772.

4.1.3 FDDI Device Interface

LPS systems software includes a FDDI device driver that implements the interface between the FDDI LAN controller board in the Data Process HWCI and the IRIX operating system. The interface supports the LPS-LP DAAC interface for data availability notification, file transfer, and transfer status reporting.

4.1.4 RAID Device Interface

LPS systems software includes a RAID device drivers that implement the interface between the RAID storage arrays making up the Raw Data Capture and Data Transfer Store HWCIs and the IRIX operating system as well as utilities and diagnostics for managing and troubleshooting the RAID storage arrays.

4.2 LPS COTS Software

LPS COTS software includes the Oracle DBMS and the NCSA HDF software package. Section 4.2.1 describes the Oracle DBMS. Section 4.2.2 describes the NCSA HDF package.

4.2.2 Oracle DBMS

Oracle is a relational database management system. The decision to specify Oracle as the LPS DBMS was based on the results of a comparison of databases performed by the Pacor II project in 1992. That comparison's findings remain valid.

Oracle provides standard management services for information stored as a set of relations (tables). It also manages the storage of views, rules, triggers, constraints, and procedures within a database. Standard database management features include transaction based commit and rollback, two-phase commit for distributed databases, journaling and checkpointing, and database consistency point recovery after catastrophic system failures. It includes [optional] modules for forms-based user interface, report generation, stored procedure definition, and C language Applications Programming Interface (API).

Oracle uses a SQL based data definition and manipulation language. Oracle allows the creator to specify not only the relational structure of a table, but the format and disk area in which it is stored. Oracle allows the definition of multiple views of tables in the database and supports full query and limited modification capabilities of underlying tables through the view. Oracle allows the definition of indexes of up to 16 attributes. Oracle's clustering ability allows the storage of related tables interleaved in the same disk area. Oracle allows the creation of snapshots which store locally the results of a query over tables in a remote database as well as the definition of an automatic periodic refresh interval to maintain the snapshot's currency.

Oracle allows the definition and initialization of automatic sequence number attributes attached to rows of a table.

Oracle includes a cost-based query optimizer. To further improve performance, Oracle supports multithreaded servers and automatically determines when queries can be shared between users. Oracle uses configurable read-ahead and write-behind threads.

Oracle includes both line-oriented and forms-based SQL user interfaces for data definition, data manipulation, and database administration. Database access is controllable by passwords and access permissions. PL/SQL is Oracle's procedural language with embedded SQL; it can be used to define stored procedures. Oracle includes a C pre-compiler and run-time libraries that provide an embedded SQL API.

Oracle includes standard database administration utilities including save/restore, data import/export, system configuration, and access permission and system privilege control. Access permission and privilege granularity is at the table and operation level. Oracle allows the definition of roles, a set of system privileges and data access privileges on database objects that may be granted/revoked to a user as a unit. Oracle's auditing capabilities allow the generation of access histories for system tuning.

The LPS design includes use of the following Oracle services.

- Oracle manages LPS quality and accounting information and set-up tables.
- Operators update LPS set-up tables through Oracle's user interface.
- The Oracle report generator creates LPS quality and accounting data reports.
- LPS applications software uses the Oracle API to retrieve execution parameters from the database and to insert quality and accounting information.

4.2.3 NCSA HDF

NCSA HDF is a collection of run-time libraries and utilities that support creation and manipulation of files HDF standard. The file format standard, run-time libraries, and utilities were developed by NCSA with the goal of allowing data sharing via files in a standard, flexible, and machine-independent format. HDF format has been adopted as a standard for Earth sciences files stored in the Earth Observing System Data and Information System (EOSDIS) of which the LP DAAC is a member. HDF format is therefore required for Level 0R files to be transferred to the LP DAAC (see Applicable Document 5).

LPS applications software is linked with HDF run-time libraries to create Level 0R files in HDF format. LPS operators may use HDF utilities to view and edit HDF files directly.

5. Operations Design

This section provides an operational overview of the system and details on the LPS Operations design. Examining system operations provides information on relationships of events in time and operator interfaces. Investigating system operations provides an understanding of sequence of events, concurrency, and workload. This section describes the LPS normal and contingency operational scenarios and timelines.

5.1 LPS Operational Overview

LPS is charged with the responsibility of accepting real-time Landsat 7 raw wideband data, processing it, and making it available to the LP DAAC. This process consists of three distinct actions. First, the data is captured in real-time to disk in its raw form. Next, LPS performs Level 0R processing of the data. Output data files are generated on a sub-interval basis. The third step is the transfer of files to the LP DAAC.

Other operations required to support the LPS are maintaining a short term raw data capture store, configuring the processing strings for data capture, and general maintenance of the software and system.

5.2 Operational Concepts

Data is only sent from the satellite when it is in view of a ground station (the LGS or an international ground station). The satellite is in view of the ground station for two or three orbits in a row, this is called a "contact set". A contact set occurs twice per day. The time between the start of each contact in a set is approximately 90 minutes. Due to the nature of the contact schedule and the processing requirements, the LPS has a 24 hour per day 7 days per week operational schedule.

The Landsat satellite sends one or two 150 Mbps data streams to the LGS. Each 150 Mbps stream is split into a pair of 75 Mbps data streams by LGS. LPS receives the four raw wideband data streams from LGS on a satellite contact basis. Each data stream feeds into its own dedicated LPS processing string.

An interval is a period in a single contact where the instrument was switched on, data was recorded, and then the instrument was switched off. A sub-interval occurs when a instrument on/off period cannot be transmitted to the ground in a single contact. Another cause for sub-interval creation is an artifact of the ground link communication process where the "I" and "Q" channels switch data streams. The LGS hardware detects this change, but continues to send the switched data streams to LPS. The net result of this is that the physically separate LPS strings suddenly receive a different channel. Data formats for the two channels are different and require different processing and produce different output files. Each time a sub-interval is detected, the output files are closed and a new set of output files started.

Each LPS string generates level 0R, browse and metadata files on a subinterval basis. The files are copied to the LP-DAAC from the LPS string's local disk storage. Eventually, the output files from a pair of LPS strings are combined to create full scene information. It is assumed that this is the responsibility of the LP DAAC.

LPS ensures that all data captured is processed and either reported as bad data or written to the output files.

Automation is used in the design whenever possible and when not constrained by budgetary considerations. The data capture and data processing functions must be started manually, but all normal processing functions (except for tape changing) after that are performed automatically.

5.3 Normal Operations

There are many operational procedures required to successfully meet the LPS requirements. The LPS system is configured, data capture is started and stopped, the data is processed into files as well as saved to tape for a short term storage, reports are requested and reviewed, and re-process requests are satisfied. A range of services supporting the operational system are also provided by/performed on a separate standby LPS string.

Figure 5-1 shows the interaction of the various LPS subsystems as they perform normal LPS processing.

5.3.1 LPS Operator Activities

Although the LPS physical architecture consists of four physically independent logically identical processing strings and one standby string, control of those strings is coordinated from the operator's point of view. All of the strings are controlled from a single terminal. Control of the standby string does not affect control of the operational strings. Metadata is automatically collected on the amount of data received, processed and delivered on a Landsat 7 contact period, and on a daily basis. The LPS operator requests these reports as part of normal LPS operations.

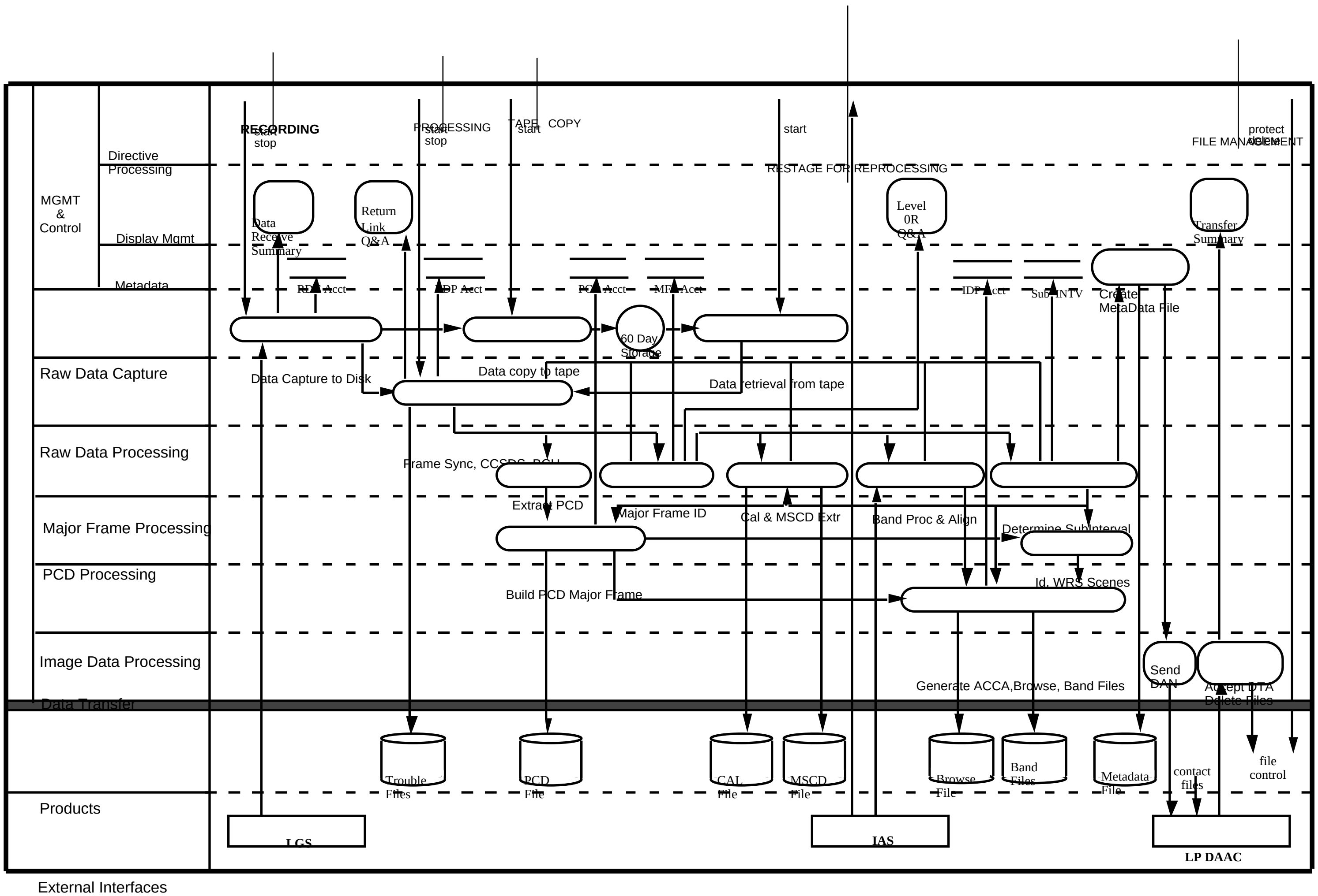


Figure 5-1: Subsystem Operational Flow Data Flow Diagram

The following are the operator functions required for LPS.

- Configure operational strings (table updates, etc.).
- Configure the LP DAAC communication interface.
- Start/stop LPS.
- Start/stop data collection.
- Start short term storage tape copy
- Start/stop data processing
- Monitor ongoing data processing.
- Override automatic operations.
- Start re-process job
- Request operational reports
- Manage files
- Configure the fifth string for testing, maintenance, training and development, and failover.

5.3.2 Setup LPS

There are two levels of setup required for LPS processing. Long term setup and data capture setup. Note that any operations which apply for a single string are performed for all four strings. It is expected that there will be automated utilities which assist the operator in performing duplicate actions across different strings.

5.3.2.1 Configuration Parameters and Tables

The LPS operator performs long term setup operations by entering the sensor alignment table and entering configuration parameters which are required by the LPS software. All configuration setup procedures are manual, but the option of using electronic means to update these tables is not ruled out. The setup tables must be verified as identical across all operational strings.

LPS will receive the ETM+ sensor alignment information from the IAS only a few times during the Landsat 7 mission duration. This data will be on hardcopy or in portable electronic form readable by LPS workstations. The LPS operator will load the data into LPS for use in integer-pixel alignment processing of the ETM+ sensor data (during generation of Level 0R files).

LPS configuration parameters will be tuning mechanisms used to optimize LPS performance or allow for changes in hardware or software configurations.

5.3.2.2 Data Capture Setup

Data capture setup involves all of the procedures required to ensure LPS is in a state ready for data receive. This involves schedule coordination and verification of operational readiness.

LPS operators receive a schedule of Landsat 7 contact times. These contact times are cyclic and repeat on a 16 day cycle. The schedule allows the operator time to prepare for data capture. The operator coordinates with both LGS and LP-DAAC operators to ensure the data connections are established and functioning properly. The operator ensures that LPS software is running on all operational strings. Any setup required by the specific hardware configuration of each string is performed at this time. The operator may request that LGS run a test data stream to LPS in order to test the connection and to ensure that LPS produces the correct output. The operator monitors the LPS hardware/software operational readiness display to verify the correct configuration for LPS operational strings. The operator also ensures that each string has enough disk space available to capture the raw data and to store the Level 0R, browse and metadata files. This is assured by following operational procedures described in 5.3.2, "Short Term Raw Data Tape Storage". If space is not available because those procedures have not been followed, it is an operational decision whether to delete previously captured data to make room for the new data, or to forego capturing the new incoming data. If necessary due to excessive processor load, all other LPS functions will be suspended during the data capture function.

5.3.3 Perform Data Capture

The LPS Operator receives a schedule of the Landsat 7 contact periods from the LGS. The schedule is used to initiate LPS data capture. LPS will use a manual interface to begin and end data capture. The operator will know the start time of the data stream and will need to start the LPS data record operation approximately 15 seconds before the start of actual data to be sure that no initial data is missed. LPS data capture will be stopped approximately 15 seconds after scheduled data end to ensure that all data sent by LGS was captured by LPS. The short duration between the actual start and stop times of data capture and the scheduled transmission start and stop times is intended to minimize the number of noise bits captured. Because the LGS clock signal is continuous, noise bits are captured before and after the actual contact, when there is no data on the LGS data signal.

Automating the data capture function with either data driven capture or schedule driven capture is desirable, and remains an open issue.

The LPS must coordinate the receipt of return link wideband data with the LGS by insuring that each independent LPS string interfaces with the correct LGS output channel. Prior to data capture, the operator can verify the LPS functions on a LPS string basis by requesting and capturing a predefined test data set.

Each LPS string will capture the LGS data stream in real-time to its own disk space in raw form. The LPS string will generate the return link statistics for contact start and stop time, received data volume, approximate number of Landsat 7 images received, and the tape label identifier for the contact short term storage. The operator will report the return link statistics for each string to LGS and MOC operations.

5.3.4 Short Term Raw Data Storage

The copy to short term storage function may be suspended at any time by the operator. This suspension does not affect any other function. Copying resumes when the operator re-activates the function.

By end of the capture period the entire set of data captured during the contact is stored on disk. In addition to being processed, this data is transferred to removable media using low cost tape drives. Both processing and copy to tape may take place at the same time.

As part of the setup for each data capture session, the operator selects and labels a separate tape for each string involved in data capture. The tape labels include the contact period start/stop time, the date, and the LPS string used to store data.

The operator mounts the required tapes in the tape device for each string and initiates the LPS function to copy the raw data to tape after the data capture session ends.

The operator is required to manually update the count of how often the particular tape has been used. This may involve keeping a master list of all the tapes and the number of times a tape has been used. The number of times a tape can be re-used depends on the media selected. An error message will be displayed if tape quality has deteriorated so that it is unwriteable. If an error message is displayed concerning the tape, the operator will replace the damaged tape with a fresh tape and restart the tape copy.

After the raw data is copied, the tapes are removed and stored chronologically by contact period. The raw data is retained on tape for a minimum of 60 days. At four tapes per contact and an average of five contacts per day for 60 days, the total number of tapes will be 1200 tapes.

5.3.5 Level 0R Processing

Once all data is captured to the disk, the operator issues a command and LPS begins processing the data into LPS output files. LPS removes the communication artifacts from the raw data and generates return link quality and accounting information. LPS processes data on a contact basis, but generates output files on a subinterval basis.

During LPS level 0R processing, the operator will monitor the ongoing LPS functions and the data going through the system. The operator uses the LPS readiness display to ensure continuing operation of the system. The operator also examines the return link quality and accounting report to verify that data was received.

5.3.5.1 Output Files

LPS produces files on a sub-interval basis. This means that when LPS is through processing a sub-interval, it closes the currently open output data files and begins writing new ones. For each sub-interval, each LPS string generates several Level 0R Instrumentation data files, a calibration file, a mirror scan correction file, a payload correction file, a metadata file, and possibly a browse file depending on the data format**.**

5.3.5.2 Trouble Files

Trouble files are generated when the LPS processing detects bad data. (i.e. data fails R-S, CRC, and BCH error detection/correction) The failed CADUs are written to trouble files for later analysis. Operators will need to be aware of the space being used by these files. The files will either be deleted or can be stored, off-line, for future reference. These trouble files are intended for LPS internal use only.

5.3.6 Transfer Files to LP DAAC

The transfer files to LP DAAC function may be suspended at any time by the operator. This suspension does not affect any other function. File transfer resumes when the operator re-activates the function.

When an LPS string completes the processing of a contact, it automatically initiates the transfer of LPS output files to the LP-DAAC. A DAN is created on a contact basis per string. The DAN is sent to the LP DAAC over the LPS/LP DAAC interface, indicating that the files are ready for transfer. All of the files for each sub-interval of a contact are listed in the DAN.

The LP DAAC transfers the files and sends a file receipt notification back to the LPS. The LPS must be able to retain files until the LP DAAC transfers the files successfully. The LPS provides a manual override capability to allow the operator to retain files on-line. The LP DAAC sends a DTA to the individual LPS string when all files from the contact have been transferred. The LP DAAC is responsible for correlating sub-interval files received from separate strings.

Once the file transfer notification is sent and the files have been transferred by the LP DAAC successfully, the LPS deletes the files.

The operator uses information provided by LPS to monitor this automated activity and takes appropriate action when the interface fails. A summary report of data received, files processed, and files delivered is produced on a contact and a daily basis. The report is used to verify that LPS is functioning as expected and to verify that data entering LPS results in the proper data files leaving LPS.

5.3.7 Re-Processing

LPS is required to support reprocessing of received raw wideband data equivalent to about 10% of its daily received volume. The LPS operator will receive a verbal or written request from the IAS to re-process a particular contact. The request may be for a single string or for a pair of strings. Since the raw data is captured and stored on a contact basis, requests to re-process a sub-interval require the LPS to be capable of identifying the contact period, retrieving the data from the removable media, and re-processing the data on a contact period basis. The operator identifies and locates the appropriate short term raw data storage tape, prepares the system to accept data, mounts the tape, and starts the re-process task. The LPS software does not differentiate between data captured from the satellite and placed on disk and data being input directly from tape. From this point on, no additional processing is required to re-process the data. After the tape usage is complete, the operator returns the tapes to the short term storage. When LPS re-processing is complete, the LPS output files are transferred as usual to the LP-DAAC. The LP-DAAC differentiates the re-processed data from data previously sent using the file generation dates.

5.3.8 Operate Standby String

The standby string is used for software development, maintenance and testing as needed, as well as for training purposes. The process of upgrading software and equipment on strings places a special constraint on the use of the standby string. If the upgrade affects (or alters) the LPS output files, then the upgrade must be performed in a way which ensures that each string pair uses the same software to generate the files. The procedure used will be to upgrade the standby string and test it while the operational LPS system performs the data capture and processing task. Then during slack time, only one of the 4 operational strings needs to be upgraded in order to make a pair. This process is repeated during the next contact/slack time set to upgrade all strings to the new software level. If confidence is high in the upgrade procedure and the data capture operation will not be impacted, all four strings could be upgraded during the same slack period. Each time the standby string is switched for an operational string, the LGS operator is notified of the change required to the matrix switch.

5.4 Contingency Operations

5.4.1 LGS Interface Fails

An LGS interface failure must be detected by either the LPS operator or the LGS operator. The operator which discovers the problem will call the other operator.

In the event of an LGS interface failure, the LPS cannot capture data sent from the LGS. However, the processing of previously captured wideband data and the re-processing operations continue. If the failure occurs while raw data is being captured, and the LPS is unable to capture the data from a complete contact period, then the operator verbally reports the data loss to the MOC and the LP-DAAC. The partially captured contact period data will be processed. If the point of failure is the communications link between the LPS and the LGS, the LGS operator switches to a backup communications link. The LGS operator coordinates the switch with the LPS operator and the LPS operator performs any configuration changes needed for the LPS string.

When the point of failure has been identified and resolved, the LPS operator tests the data capture operation by capturing a test data set sent from the LGS. The sending of a test data set must be coordinated between the LPS operator and the LGS operator. The LPS operator reports the successful receipt and processing of the test data set to the LGS operator. LPS then continues with normal operations.

5.4.2 LPS String Failure

Whenever an LPS string fails, the operator must take immediate action to take it off-line and replace it with the standby string. This requires coordination with the LGS and LP-DAAC operators. The LGS operator changes the matrix switch so that the data stream from the "down" string is moved to the standby string. The LP-DAAC operator must be notified that the string is down and that any files they are attempting to retrieve are now unavailable. The LPS operator configures the "standby" string as a stand in for the "down" string and brings it on-line. The LGS operator sends a test data stream to the replacement LPS string and the LPS operator compares the output files to a known data set. If the files and contents match, then LPS is again ready for data capture. Normal LPS operations continues with the next satellite contact and maintenance is notified of the problem with the "down" string. It is important that this switch-out procedure be performed as quickly as possible. Any configuration table changes required are performed as part of the switch-over.

5.4.2.1 LPS String Failure During Data Capture

Since the raw Landsat 7 data is being captured in real time to the disk, any data which goes to a string after it fails is lost. Any data already captured by that string is inaccessible until the string is repaired. If the capture disk is the element that failed, it is possible that the contact data will be destroyed. Once the string is repaired, the captured data can be processed. All sub-intervals except for the sub-interval during which failure occurred are considered valid and are processed.

5.4.2.2 LPS String Failure During Data Processing

If an LPS string fails during processing, the string is replaced. If the failure occurred before the transfer to tape storage was complete, the data recovery process is the same as that for a string failure during data capture. If the string failed after the data was copied to tape but before processing completed, the string is switched with the standby string and the data tape is used as the data input source.

5.4.2.3 LPS String Failure During File Transfer to LP-DAAC

If an LPS string fails during the file transfer to LP-DAAC, the string is replaced and the data re-processed from tape. the LPS operator will notify the LP-DAAC operator of the string failure. Any DANs which were sent to the LP-DAAC will need to be canceled by the LP-DAAC operator.

5.4.3 LP-DAAC Interface Fails

The failure of the LP-DAAC interface may be caused by either the failure of the communications link between the LPS and the LP-DAAC and/or by the failure of an LP-DAAC component designated to receive LPS Files from the LPS.

In either or both failure scenarios the failure must be detected. This detection could be through direct notification by the LP-DAAC operator or by LPS monitoring of disk space available for transfer storage. Once detected, the LPS and the LP-DAAC operators must communicate the failure. The LPS raw data capture continues. The raw wideband data is written to disk and written to the 60-day removable storage. The LPS operator over-rides LPS processing and file generation until the LP-DAAC interface returns to normal operations.

An LP-DAAC failure which continues for an extended period of time should cause no change in the LPS data capture scenario. LPS will continue to capture the data to the disk and the transfer it to the short term tape storage. If the data capture disk becomes full, the LPS operator makes room on the disk by deleting data which has been captured and copied to short term storage but not yet processed. The data copied to short term storage but not processed must be identified for later processing during LPS slack time.

If the point of failure is the communications link between the LPS and the LP-DAAC then the LP-DAAC operator switches to any backup communications equipment and coordinates the switch with the LPS operator. The new link is verified before LPS file generation is resumed.

Once the point of failure has been identified and repaired, the LPS operator is notified by the LP-DAAC operator. The file transfer operation resumes. The LPS file generation resumes. Process directives are issued to process the contact periods that were captured and stored but not processed during the LP-DAAC interface failure. The LPS uses the 60-day raw wideband data store as the source for all data that has not been processed and is not currently stored on disk.

5.5 Operational Timeline

LPS performs data capture, processing, re-processing and makes output files available to the LP-DAAC. When these functions are performed is determined by the LPS operational timeline. One important aspect of a timeline is to determine if enough time is available to perform a given task. Figure 5-2 "LPS Operational Timeline" shows that there is sufficient time for LPS operations given the following assumptions:

- Data capture start and duration times are known because of the predictability of the satellite orbit and proximity to the EDC.
- LPS processes data at a minimum speed of 7.5 Mbps.
- LPS re-processes approximately 10% of its data.

- Data capture is to disk, processing can begin as soon as data capture is complete and can be suspended at any time to perform the next data capture.
- LPS hardware and software maintenance can be completed during slack time.

While these assumptions represent a best case scenario, it is to be noted that LPS requirements are met even in the worst case scenario.

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LPS Operational Timeline - EDC 0 Degree Acquisition Circle - Day 1 (24 Hours)

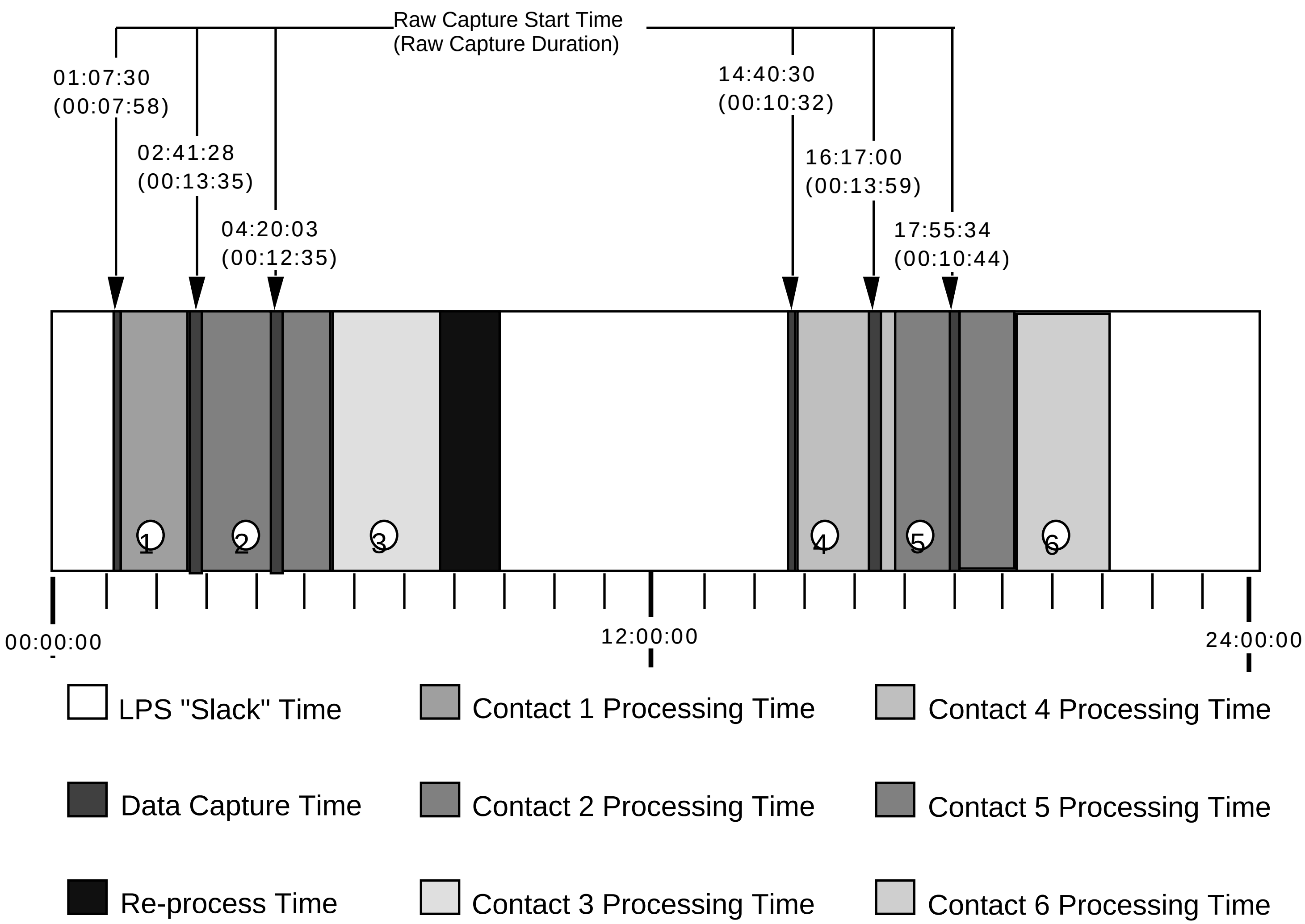

Figure 5-2: LPS Operational Timeline

Glossary

Bit Error Rate (BER): The number of binary digits (bits) received in error divided by the total number of bits received over a specified time period.

Browse Image File: A reduced data volume file of the Level 0R data which can be viewed to determine general ground area coverage and spatial relationships between ground area coverage and cloud coverage. This file contains reduced resolution scenes of the full resolution scene data contained in the Level 0R instrument data files of a sub-interval.

> **Monochrome Browse**: Contains browse image data for a single band.
>
> **Multi-band Browse**: Contains browse image data from 3 predefined bands.

CCSDS Services: Services that are described in the Consultative Committee for Space Data Systems (CCSDS) Recommendations for Space Data Systems Standards, as specified in Applicable Document 1.

Channel Access Data Unit (CADU): A VCDU or coded VCDU (CVCDU) that has been prefixed and delimited by a synchronization marker, as specified in Applicable Document 1.

Daily average: The average computed over any continuous 24-hour period.

Data Capture: The receipt and storage of return link mission data at the CADU level.

Delay: The time elapsed between receipt of the last bit of the last data unit for a data product by a facility and the start of transmission of the first bit of that data product out of the same facility.

Interval: The time duration between the start and stop of an imaging operation (observation) of the Landsat 7 ETM+ instrument.

Landsat 7 Contact Period: The time duration between the start and end of wideband data transmissions from the Landsat 7 spacecraft to a ground station.

Level 0R Files: The reformatted, unrectified sub-interval data having a sequence of pixels which are spatially consistent with the ground coverage and appended with radiometric calibration, attitude, and ephemeris data.

> **Level 0R Instrument Data File**: Each file contains the image data from a single band in a single subinterval. The data is grouped by detectors, i.e., for a given major frame, detector 1 data is followed by

detector 2 data, etc. Reverse scans are reversed. This data is nominally aligned using fixed and predetermined integer values (provides alignment for band offset, even/odd detectors, and forward and reverse scans). Quality indicators are appended for each major frame.

Calibration File: One file is created for each sub-interval. This file contains all of the calibration data received on a major frame basis for a given sub-interval. This is the data received after the Scan Line Data (which follows the End of Line Code) and before the next major frame sync, as described in Applicable Document 3. The data is grouped by detectors, i.e., for a given major frame, detector 1 data is followed by detector 2 data, etc. Reverse scans are reversed. The time of the major frame corresponding to this data is appended, as well as the status data.

Mirror Scan Correction Data (MSCD): One file is created for each sub-interval. This file contains the Scan Line Data extracted from the two minor frames following the End of Line Code in each major frame of the sub-interval . The Scan Line Data includes the first half scan error (FHS ERR), the second half scan error (SHS ERR), and the Scan direction (SCN DIR) information. The time of the major frame corresponding to this data is appended.

Payload Correction Data (PCD): One file created for each sub-interval. This file contains the PCD major frames received during a subinterval on a full PCD cycle basis. Quality indicators will be appended on a minor frame basis.

Level 0R Quality and Accounting Data: The data quality and accounting information collected by the LPS, on a sub-interval basis, from processing of the ETM+ major frames constructed from the wideband VCDUs received during a Landsat 7 contact period.

LPS Files: The generic term used to denote the grouping of Level 0R, the browse and the metadata files for a single sub-interval.

LPS String: A functional entity of the LPS responsible for end-to-end processing of the raw wideband data received from a return link channel (I or Q) of the X-band downlink data captured by the LGS.

Mean Downtime (MDT): The period of time consisting of mean time to repair (MTTR) plus administrative and logistics delays.

Mean Time Between Failures (MTBF): The mean time between failures measured during a specified operating period.

Mean Time To Repair (MTTR): The period of time consisting of the mean time required from failure detection, through troubleshooting, fault localization, removal and replacement of failed LRUs, adjustment/calibration of repaired equipment and verification that the specified performance requirements are met.

Mean Time To Restore (MTTRes): The mean time required to restore functionality, performance, and operational state existing prior to any failure.

Metadata: One metadata file is created for each sub-interval. The metadata contains information on the Level 0R data provided in the sub-interval, the names of the Level 0R instrument data, calibration data, payload correction data, mirror scan correction data and browse image files associated with the sub-interval. Metadata also contains quality and accounting information on the return link wideband data used in generating the level 0R file(s). In addition, metadata includes quality and accounting information on received and processed PCD, and cloud cover assessment for the WRS scene contained in the sub-interval. The metadata is used by the LP DAAC users to determine the sub-interval and/or WRS scene level quality of the Level 0R data stored in the LP DAAC archive before ordering it on a cost basis.

Mission Data: Spacecraft, instrument, and other data for a specific mission. Mission Data includes spacecraft return link data in raw and processed form.

Mission Critical Functions:

- Receive wideband data
- Generate Level 0R File(s)
- Generate Browse File(s)
- Generate Metadata File(s)
- Control LPS functions

Non-mission Critical Functions:

- Software maintenance
- Software development
- Preventive Maintenance
- Training

On-line: A capability or combination of capabilities is defined as being on-line when it is available for or currently supporting its allocated operational requirements.

Return Link Data: Mission Data originating on a spacecraft for transmission to the ground.

Return Link Quality and Accounting Data: The data quality and accounting information collected by LPS from CCSDS Grade 3 and BCH error detection and correction processing of the raw wideband data received from LGS on a Landsat 7 contact period basis.

Sub-Interval: A segment of raw wideband data interval received during a Landsat 7 contact period. Sub-intervals are caused by breaks in the wideband data stream due to communication dropouts and/or the inability of the spacecraft to transmit a complete observation (interval) within a single Landsat 7 contact period. The largest possible sub-interval can be as long as a full imaging interval. The smallest possible sub-interval can be as small as one full ETM+ scene with a time duration of approximately 24 seconds.

Virtual Channels: A CCSDS architectural concept whereby a single physical channel may be shared by different types of users by creating multiple, apparently parallel "virtual" paths through the physical channel, as specified in Applicable Document 1.

Virtual Channel Data Unit (VCDU): A fixed-length CCSDS AOS data structure which is used bidirectionally for space/space or space/ground communications. A VCDU that includes forward error correction coding is referred to as a CVCDU and is implied by references to VCDUs, as specified in Applicable Document 1.

Acronym List

ACCA	Automatic Cloud Cover Assessment
Ao	Operational Availability
AOS	Advanced Orbiting Systems
API	Applications Programming Interface
BCH	Bose-Chaudhuri-Hocquenghem (error detection and correction scheme)
BER	Bit Error Rate
CADU	Channel Access Data Unit
CCB	Configuration Control Board
COTS	Commercial Off-the-Shelf
CPU	Central Processing Unit
CCSDS	Consultative Committee on Space Data System
CRC	Cyclic Redundancy Check
CVCDU	Coded VCDU
DAN	Data Availability Notice
DBMS	Database Management System
DD	Data Dictionary
DDE	Data Dictionary Entry
DDF	Data Distribution Facility
DSP	Digital Signal Processing
DTA	Data Transfer Acknowledgment
ECS	EOSDIS Core System
EDC	EROS Data Center
EDAC	Error Detection and Correction
EOL	End of Line
EOSDIS	Earth Observation Data Information System
EROS	Earth Resources Observation System
ESMO	Earth Science Mission Operations
ETM+	Enhanced Thematic Mapper Plus (instrument)
FHS ERR	First Half Scan Error
FTAM	File Transfer Access and Management
FTP	File Transfer Protocol
F&PR	Functional and Performance Requirements
F&PS	Functional and Performance Requirements
GByte	Gigabyte

GSFC	Goddard Space Flight Center
HWC	Hardware Component
HWCI	Hardware Configuration Item
IAS	Image Assessment System
ID	Identification
IDD	Interface Data Description
IDPS	Image Data Processing Subsystem
IPD	Information Processing Division
LAN	Local Area Network
LCC	life-cycle cost
LDTS	LPS Data Transfer Subsystem
LGS	Landsat 7 Ground Station
LPS	Landsat 7 Data Processing System
LP DAAC	Land Processes Distributed Active Archive Center
LRU	Line Replaceable Unit
MACS	Management and Control Subsystem
Mbps	megabits per second
MFPS	Major Frame Processing Subsystem
MSCD	Mirror Scan Correction Data
MDT	Mean Downtime
MOC	Mission Operations Center
MO&DSD	Mission Operations and Data Systems Directorate
MTBF	mean time between failures
MTTR	mean time to repair
MTTRes	mean time to restore
NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
NCSA	National Center for Supercomputing Applications
PCD	Payload Correction Data
PCDS	PCD Data Processing Subsystem
PN	Pseudo-Random Noise
RAID	Redundant Array of Inexpensive Devices
RAM	Random Access memory
RDCS	Raw Data Capture Subsystem
RDPS	Raw Data Processing Subsystem
RMA	Reliability, Maintainability, and Availability
R-S	Reed-Solomon (error detection and correction scheme)

SCCS	Source Code Control System
SCN DIR	Scan Direction
SGI	Silicon Graphics, Incorporated
SHS ERR	Second Half Scan Error
SMP	Systems Management Policy
SN	Space Network
SQL	Structured Query Language
SSDM	Structured Systems Design Methodology
STDN	Spaceflight Tracking and Data Network
SVR4	System V Release 4
TBD	To Be Defined/Determined
TBR	To Be Resolved
VCDU	Virtual Channel Data Unit
VCDU-ID	VCDU Identifier
VME	Versa Module European
WRS	World Reference System

Appendix A. LPS Requirements Allocation Matrix

REQ #	REQUIREMENT SUMMARY	RDCS	RDPS	MFPS	PCDS	IDPS	MACS	LDTS
3.1.1	LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.	✓	✓	✓	✓	✓	✓	✓
3.1.2	LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.	✓	✓	✓	✓	✓	✓	✓
3.1.3	LPS shall provide the capability to receive, record and process 4 simultaneous wideband data inputs from the LGS, and deliver LPS output files.	✓	✓	✓	✓	✓	✓	✓
3.1.4	LPS shall process wideband data inputs from LGS on a Landsat 7 contact period (return link wideband data recording session) basis.	✓	✓					
3.1.5	LPS shall process wideband data to generate LPS output files on a received sub-interval basis.			✓	✓	✓	✓	
3.1.6	LPS shall generate Landsat 7 return link quality and accounting data on a Landsat 7 contact period basis for each wideband data input.	✓	✓					
3.1.7	LPS shall generate Level 0R quality and accounting data on a sub-interval basis for each LPS wideband data input.			✓				
3.1.8	LPS shall provide the capability to reprocess wideband data.	✓					✓	
3.1.9	(requirement renumbered to 3.1.10.1)							
3.1.10	The LPS shall provide an interactive intervention capability to detect and correct abnormal system conditions during LPS data capture and processing activities.	✓	✓	✓	✓	✓	✓	✓
3.1.10.1	LPS shall provide a system start-up capability.						✓	
3.1.10.2	LPS shall provide a system shut-down capability.						✓	
3.1.10.3	LPS shall provide the capability to generate and report LPS error messages		✓				✓	
3.1.10.4	LPS shall provide the capability to isolate system faults.						✓	

REQ #	REQUIREMENT SUMMARY	RDCS	RDPS	MFPS	PCDS	IDPS	MACS	LDTS
3.1.10.5	LPS shall provide the capability to recover from system faults.						✓	
3.1.10.6	LPS shall provide the capability to test LPS functions and external interfaces.	✓	✓	✓	✓	✓	✓	✓
3.1.10.7	LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.	✓	✓	✓	✓	✓	✓	✓
3.1.10.8	LPS shall provide the capability to support end-to-end testing of LPS functions.	✓	✓	✓	✓	✓	✓	✓
3.1.11	LPS shall provide the capability to control LPS operations.	✓	✓				✓	
3.1.12	LPS shall provide the capability to monitor LPS operations.	✓	✓				✓	
3.1.13	(requirement renumbered to 3.1.10.3)							
3.1.14	LPS shall provide the capability to configure system resources to support LPS operations (with normal or fall-back configurations).						✓	
3.1.15	(requirement renumbered to 3.1.10.4)							
3.1.16	(requirement renumbered to 3.1.10.5)							
3.1.17	(requirement renumbered to 3.1.10.6)							
3.1.18	(requirement renumbered to 3.1.10.7)							
3.1.19	LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.	✓	✓	✓	✓	✓	✓	✓
3.1.20	LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.	✓	✓	✓	✓	✓	✓	✓
3.1.21	LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.	✓	✓	✓	✓	✓	✓	✓
3.1.22	LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.	✓	✓	✓	✓	✓	✓	✓
3.1.23	LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.	✓	✓	✓	✓	✓	✓	✓
3.2.1	LPS shall interface with the LGS to receive wideband data ...	✓						
3.2.2	LPS shall interface with the LP DAAC to coordinate the transfer of LPS output files to the LP DAAC ...							✓

REQ #	REQUIREMENT SUMMARY	RDCS	RDPS	MFPS	PCDS	IDPS	MACS	LDTS
3.2.3	LPS shall interface with the Mission Operations Center (MOC)						✓	
3.2.4	LPS shall interface with the Image Assessment System (IAS)						✓	
3.3.1.1	LPS shall provide the capability to receive return link wideband data inputs from LGS on a Landsat 7 contact period basis.	✓						
3.3.1.2	LPS shall provide the capability to receive return link wideband data inputs from LGS on an LGS output channel basis.	✓						
3.3.1.3	LPS shall store return link wideband data on a Landsat 7 contact period basis.	✓						
3.3.1.4	LPS shall store return link wideband data on an LGS output channel basis.	✓						
3.3.1.5	LPS shall provide the capability to retrieve stored return link data on a Landsat 7 contact period basis.	✓						
3.3.1.6	LPS shall provide the capability to retrieve stored return link wideband data on an LGS output channel basis.	✓						
3.3.1.7	LPS shall provide the capability to record return link wideband data to removable storage media, on a Landsat 7 contact period basis.	✓					✓	
3.3.1.8	LPS shall provide the capability to save removable storage media recorded with return link wideband data.	✓					✓	
3.3.1.9	LPS shall provide the capability to retrieve return link wideband data from removable storage media.	✓					✓	
3.3.1.10	LPS shall generate an LPS wideband data receive summary for each Landsat 7 contact period ...	✓						
3.3.1.10.1	LPS shall forward, via voice or FAX interface, the wideband data receive summary to the MOC within 5 minutes of data receipt at the LPS.	✓					✓	
3.3.1.11	LPS shall coordinate the receipt of return link wideband data with LGS.	✓					✓	
3.3.1.12	LPS shall maintain return link wideband data receipt capability during contact period anomalies.	✓						
3.3.1.13	LPS shall coordinate resolution of all data transfer problems with LGS.	✓					✓	

REQ #	REQUIREMENT SUMMARY	RDCS	RDPS	MFPS	PCDS	IDPS	MACS	LDTS
3.3.2.1	LPS shall perform Consultative Committee for Space Data Systems (CCSDS) Advanced Orbiting Systems (AOS) Grade-3 service on all received wideband Channel Access Data Units (CADUs) formatted in accordance with ...		✓					
3.3.2.2	LPS shall perform CADU synchronization on all received wideband data.		✓					
3.3.2.3	LPS shall provide the capability to detect and to synchronize on normal and inverted polarity wideband data.		✓					
3.3.2.4	LPS shall utilize a Search/Check/Lock/Flywheel strategy for synchronization using the following selectable tolerances...		✓					
3.3.2.5	LPS shall provide the capability to invert all bits of each CADU detected to have inverted polarity.		✓					
3.3.2.6	LPS shall provide the capability to correct bit slips, selectable between 0 and plus or minus 3 bits, in a CADU, by truncating or padding to the proper length.		✓					
3.3.2.7	LPS shall provide the capability to perform pseudo-random (PN) decoding of all received Virtual Channel Data Units (VCDUs) in accordance with...		✓					
3.3.2.8	LPS shall provide the capability to store all CADUs which have failed CCSDS Grade-3 service processing, on a Landsat 7 contact period basis.		✓					
3.3.2.9	LPS shall provide the capability to perform Bose-Chaudhuri-Hocquenghem (BCH) error detection and correction on the mission data zone contained in the VCDU (CCSDS processed data) in accordance with the Landsat 7 spacecraft data format information ...		✓					
3.3.2.9.1	LPS shall provide the capability to perform BCH error detection and correction on the data pointer zone contained in the VCDU (CCSDS processed data) in accordance with the Landsat 7 spacecraft data format information ...		✓					
3.3.2.10	LPS shall provide the capability to store all CADUs which have failed BCH error detection and correction, on a Landsat 7 contact period basis.		✓					

REQ #	REQUIREMENT SUMMARY	RDCS	RDPS	MFPS	PCDS	IDPS	MACS	LDTS
3.3.2.11	LPS shall start a new sub-interval on detection of a change in the VCID.			✓				
3.3.2.12	LPS shall provide the capability to delete fill VCDUs.		✓					
3.3.2.13	LPS shall provide the capability to collect and store Landsat 7 return link (input) quality and accounting data...	✓	✓					
3.3.2.14	LPS shall locate ETM+ minor frames in each received VCDU ...			✓				
3.3.2.15	LPS shall perform ETM+ major frame synchronization using ETM+ minor frames...			✓				
3.3.2.16	LPS shall provide the capability to band deinterleave Format 1 ETM+ data ...			✓				
3.3.2.17	LPS shall provide the capability to band deinterleave Format 2 ETM+ data ...			✓				
3.3.2.18	LPS shall provide the capability to reverse the order of data for ETM+ reverse scans.			✓				
3.3.2.19	LPS shall provide the capability to fill the following Landsat 7 data with preselected values...			✓				
3.3.2.20	LPS shall provide the capability to extract Mirror Scan Correction Data (MSCD) on an ETM+ major frame basis.			✓				
3.3.2.21	LPS shall provide the capability to extract calibration data on an ETM+ major frame basis.			✓				
3.3.2.22	LPS shall provide the capability to perform integer-pixel alignment for each ETM+ band using sensor alignment information.			✓				
3.3.2.23	LPS shall provide the capability to determine ETM+ data sub-intervals.			✓				
3.3.2.24	LPS shall provide the capability to process wideband data to level 0R.			✓	✓	✓		
3.3.2.25	LPS shall provide the capability to generate the following correlated Level 0R file(s) on a received sub-interval basis...			✓	✓	✓		
3.3.2.26	LPS shall generate Level 0R quality and accounting data, including the following information, on a sub-interval basis...			✓				
3.3.2.27	LPS shall calculate the spacecraft drift time based on information available in the PCD and append that time to the Level 0R data file.				✓	✓		

REQ #	REQUIREMENT SUMMARY	RDCS	RDPS	MFPS	PCDS	IDPS	MACS	LDTS
3.3.2.28	LPS shall append the status data contained in the VCDU mission data zone, as specified in Applicable Document 3, to Level 0R files(s) on a major frame basis.			✓		✓		
3.3.2.29	LPS shall provide the capability to identify the presence of calibration door activities using information extracted from the PCD.				✓			
3.3.3.1	LPS shall provide the capability to generate browse data for each ETM+ image sub-interval identified by LPS.					✓		
3.3.3.2	(Monochrome browse requirement deleted per RID R28)							
3.3.3.3	LPS shall provide the capability to generate multiband browse data from three predetermined bands of the ETM+ Format 1 scene data.					✓		
3.3.3.4	LPS shall include the following information on the browse data generated for each sub-interval...					✓		
3.3.3.5	LPS shall provide the capability to generate browse data using a predetermined reduction factor.					✓		
3.3.4.1	LPS shall provide the capability to synchronize on PCD bytes for assembling PCD minor frames ...				✓			
3.3.4.2	LPS shall provide the capability to fill missing PCD data.			✓	✓			
3.3.4.3	LPS shall provide the capability to assemble PCD major frames ...				✓			
3.3.4.4	LPS shall provide the capability to generate PCD file(s) on a sub-interval basis.				✓			
3.3.4.5	LPS shall provide the capability to collect and store PCD quality and accounting data on a sub-interval basis.				✓			
3.3.4.6	LPS shall provide the capability to collect and store processed PCD quality and accounting data on a sub-interval basis.				✓			
3.3.4.7	LPS shall provide the capability to perform ETM+ scene identification in accordance with the WRS scheme...				✓			

REQ #	REQUIREMENT SUMMARY	RDCS	RDPS	MFPS	PCDS	IDPS	MACS	LDTS
3.3.4.8	LPS shall provide the capability to perform automatic cloud cover assessment (ACCA) for WRS scenes.					✓		
3.3.4.9	LPS shall provide the capability to perform ACCA on both scene quadrant and full scene basis.					✓		
3.3.4.10	LPS shall use predefined comparison values in performing ACCA.					✓		
3.3.4.11	LPS shall generate Level 0R metadata (ancillary data) file(s) on a sub-interval basis.						✓	
3.3.4.12	LPS shall generate and include the following Level 0R metadata information in each Level 0R metadata file...						✓	
3.3.5.1	LPS shall notify LP DAAC on the availability of LPS files.							✓
3.3.5.2	LPS shall coordinate the reporting of file transfer problems with the LP DAAC.							✓
3.3.5.3	LPS shall provide the capability to receive notification from LP DAAC on the successful receipt of transferred LPS files.							✓
3.3.5.4	LPS shall provide the capability to store LPS data files until confirmation of successful transfer is received from the LP DAAC.							✓
3.3.5.5	LPS shall provide a manual over-ride and protected capability to delete all LPS files on a specific contact period basis.						✓	✓
3.3.5.6	LPS shall provide a manual over-ride and protected capability to retain all LPS files on-line on a specific contact period basis.						✓	✓
3.3.5.7	LPS shall provide the capability to generate LPS file(s) transfer summary, including the following information, on a daily basis							✓
3.3.6.1	LPS shall provide the capability to generate and modify LPS set-up tables from operator inputs.	✓	✓	✓		✓	✓	
3.3.6.2	LPS shall provide the capability to collect and report Landsat 7 return link quality and accounting data for each wideband data input on a Landsat 7 contact period basis.	✓	✓				✓	
3.3.6.3	LPS shall provide the capability to collect and report Level 0R quality and accounting data for each wideband data input on a sub-interval basis.			✓			✓	
3.3.6.4	LPS shall display quality and accounting data upon operator request.						✓	

REQ #	REQUIREMENT SUMMARY	RDCS	RDPS	MFPS	PCDS	IDPS	MACS	LDTS
3.3.6.4.1	LPS shall print quality and accounting data upon operator request.						✓	
3.3.6.5	LPS shall provide the capability to display LPS file(s) transfer summary upon operator request.						✓	
3.3.6.5.1	LPS shall provide the capability to print LPS file(s) transfer summary upon operator request.						✓	
3.3.6.6	The LPS shall allow the operator to select thresholds for results and errors reported by the LPS.						✓	
3.3.6.7	LPS shall automatically generate messages and alarms to alert the operator of LPS results and errors exceeding selected thresholds.						✓	
3.3.6.8	LPS shall provide the capability to manually override the LPS automated functions.	✓	✓				✓	✓
3.3.6.9	LPS shall provide the capability to selectively enable and/or disable each of the following functions: a. Receive Wideband Data b. Generate Level 0R Files c. Transfer LPS Files	✓	✓	✓	✓	✓	✓	✓
4.1.1	(requirement deleted)							
4.1.2	(requirement deleted)							
4.1.3	LPS shall provide the capability to receive and process the equivalent of 250 Landsat 7 ETM+ scenes of wideband data per day (approximately 100 GB per day).	✓	✓	✓	✓	✓	✓	✓
4.1.4	LPS shall provide the capability to receive and process the daily volume of wideband data within 16 hours of its receipt at LPS.	✓	✓	✓	✓	✓	✓	✓
4.1.5	LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data ...	✓	✓	✓	✓	✓	✓	✓
4.1.6	LPS shall provide the capability to process received wideband data at an average aggregate rate of 12 megabits per second (Mbps) (Includes 10% of overhead due to reprocessing).		✓	✓	✓	✓	✓	✓
4.1.7	LPS shall provide a maximum of 8 hours of on-line storage for temporary retention of LPS files.							✓
4.1.8	LPS shall introduce no more than one bit error in 10^9 bits.	✓	✓	✓	✓	✓	✓	✓

REQ #	REQUIREMENT SUMMARY	RDCS	RDPS	MFPS	PCDS	IDPS	MACS	LDTS
4.1.9	LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a BER of one bit error in 10^5 bits, without loss of level zero processed data and without retransmission.	✓	✓	✓	✓	✓	✓	✓
4.2.1	LGS-LPS interface shall provide the capability of transferring wideband data at a maximum rate of 75 Mbps per LPS wideband data input.	✓						
4.2.2	LPS-LP DAAC interface shall provide the capability to transfer the daily volume of LPS output files to LP DAAC at an average aggregate rate of 40 Mbps.							✓
4.3.1	LPS shall provide the capability to receive wideband data for Landsat 7 contact periods of up to 14 minutes.	✓						
4.3.2	LPS shall provide the capability to store wideband data for at least three contact periods for each LGS input until the start of a new (the fourth) contact period.	✓						
4.3.3	LPS shall provide the capability to retrieve retained wideband data at rates equal to or greater than 7.5 Mbps for each LPS input.		✓					
4.3.4	The LPS shall provide the capability to generate browse data with a reduction factor of 16 or better.					✓		
4.3.5	LPS shall provide the capability to identify ETM+ WRS scene within an accuracy of 15 meter.				✓			
4.3.6	LPS shall provide the capability to retain return link wideband data storage media for 60 days.	✓						
4.4.1	LPS shall provide an Operational Availability (A_o) of 0.96 or better for all processing functions.	✓	✓	✓	✓	✓	✓	✓
4.4.2	LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.	✓	✓	✓	✓	✓	✓	✓
4.4.3	Any LPS time to restore shall not exceed twice the required MTTRes in 99 percent of failure occurrences.	✓	✓	✓	✓	✓	✓	✓

Appendix B. LPS Requirements Allocation to Hardware/Software/Operations Matrix

The matrix below indicates the LPS system design's allocation of F&PS requirements to hardware, software, and operations. Allocation of a requirement to some category indicates that components in that category play a significant role in the requirement's satisfaction. Allocation of a requirement to operations occurs only if operational components play a significant role in satisfying the requirement, rather than merely initiating the required behavior in the system.

REQ #	REQUIREMENT SUMMARY	HW	SW	OPS
3.1.1	LPS shall provide the capability to support operations 24 hours per day, 7 days per week, on a continuous basis.	✓	✓	✓
3.1.2	LPS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.	✓	✓	✓
3.1.3	LPS shall provide the capability to receive, record and process 4 simultaneous wideband data inputs from the LGS, and deliver LPS output files.	✓	✓	✓
3.1.4	LPS shall process wideband data inputs from LGS on a Landsat 7 contact period (return link wideband data recording session) basis.		✓	
3.1.5	LPS shall process wideband data to generate LPS output files on a received sub-interval basis.		✓	
3.1.6	LPS shall generate Landsat 7 return link quality and accounting data on a Landsat 7 contact period basis for each wideband data input.		✓	
3.1.7	LPS shall generate Level 0R quality and accounting data on a sub-interval basis for each LPS wideband data input.		✓	
3.1.8	LPS shall provide the capability to reprocess wideband data.		✓	✓
3.1.9	(requirement renumbered to 3.1.10.1)			
3.1.10	The LPS shall provide an interactive intervention capability to detect and correct abnormal system conditions during LPS data capture and processing activities.		✓	
3.1.10.1	LPS shall provide a system start-up capability.	✓	✓	✓
3.1.10.2	LPS shall provide a system shut-down capability.	✓	✓	✓
3.1.10.3	LPS shall provide the capability to generate and report LPS error messages		✓	
3.1.10.4	LPS shall provide the capability to isolate system faults.	✓	✓	✓
3.1.10.5	LPS shall provide the capability to recover from system faults.	✓	✓	✓
3.1.10.6	LPS shall provide the capability to test LPS functions and external interfaces.	✓	✓	
3.1.10.7	LPS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.	✓	✓	
3.1.11	LPS shall provide the capability to control LPS operations.		✓	✓

REQ #	REQUIREMENT SUMMARY	HW	SW	OPS
3.1.12	LPS shall provide the capability to monitor LPS operations.		✓	✓
3.1.13	(requirement renumbered to 3.1.10.3)			
3.1.14	LPS shall provide the capability to configure system resources to support LPS operations (with normal or fall-back configurations).	✓	✓	✓
3.1.15	(requirement renumbered to 3.1.10.4)			
3.1.16	(requirement renumbered to 3.1.10.5)			
3.1.17	(requirement renumbered to 3.1.10.6)			
3.1.18	(requirement renumbered to 3.1.10.7)			
3.1.19	LPS shall provide monitoring test points and indicators to verify proper operation of system capabilities and components.	✓	✓	
3.1.20	LPS shall provide the capability to support software maintenance during LPS normal operations on a non-interruptive basis.	✓	✓	
3.1.21	LPS shall permit corrective maintenance to be performed on failed equipment while the remainder of the system is actively satisfying mission critical functions not supported by that equipment.	✓	✓	
3.1.22	LPS shall provide the capability to support preventive maintenance during LPS normal operations on a non-interruptive basis.	✓	✓	
3.1.23	LPS shall provide the capability to support operator training during LPS normal operations on a non-interruptive basis.	✓	✓	✓
3.2.1	LPS shall interface with the LGS to receive wideband data ...	✓	✓	✓
3.2.2	LPS shall interface with the LP DAAC to coordinate the transfer of LPS output files to the LP DAAC ...	✓	✓	
3.2.3	LPS shall interface with the Mission Operations Center (MOC)			✓
3.2.4	LPS shall interface with the Image Assessment System (IAS)			✓
3.3.1.1	LPS shall provide the capability to receive return link wideband data inputs from LGS on a Landsat 7 contact period basis.	✓	✓	✓
3.3.1.2	LPS shall provide the capability to receive return link wideband data inputs from LGS on an LGS output channel basis.	✓	✓	✓
3.3.1.3	LPS shall store return link wideband data on a Landsat 7 contact period basis.	✓	✓	
3.3.1.4	LPS shall store return link wideband data on an LGS output channel basis.	✓	✓	
3.3.1.5	LPS shall provide the capability to retrieve stored return link data on a Landsat 7 contact period basis.	✓	✓	
3.3.1.6	LPS shall provide the capability to retrieve stored return link wideband data on an LGS output channel basis.	✓	✓	
3.3.1.7	LPS shall provide the capability to record return link wideband data to removable storage media, on a Landsat 7 contact period basis.	✓	✓	✓
3.3.1.8	LPS shall provide the capability to save removable storage media recorded with return link wideband data.	✓		✓
3.3.1.9	LPS shall provide the capability to retrieve return link wideband data from removable storage media.	✓	✓	✓
3.3.1.10	LPS shall generate an LPS wideband data receive summary for each Landsat 7 contact period ...		✓	

REQ #	REQUIREMENT SUMMARY	HW	SW	OPS
3.3.1.11	LPS shall coordinate the receipt of return link wideband data with LGS.			✓
3.3.1.12	LPS shall maintain return link wideband data receipt capability during contact period anomalies.	✓	✓	
3.3.1.13	LPS shall coordinate resolution of all data transfer problems with LGS.			✓
3.3.2.1	LPS shall perform Consultative Committee for Space Data Systems (CCSDS) Advanced Orbiting Systems (AOS) Grade-3 service on all received wideband Channel Access Data Units (CADUs) formatted in accordance with ...		✓	
3.3.2.2	LPS shall perform CADU synchronization on all received wideband data.		✓	
3.3.2.3	LPS shall provide the capability to detect and to synchronize on normal and inverted polarity wideband data.		✓	
3.3.2.4	LPS shall utilize a Search/Check/Lock/ Flywheel strategy for synchronization using the following selectable tolerances...		✓	✓
3.3.2.5	LPS shall provide the capability to invert all bits of each CADU detected to have inverted polarity.		✓	
3.3.2.6	LPS shall provide the capability to correct bit slips, selectable between 0 and plus or minus 3 bits, in a CADU, by truncating or padding to the proper length.		✓	✓
3.3.2.7	LPS shall provide the capability to perform pseudo-random (PN) decoding of all received Virtual Channel Data Units (VCDUs) in accordance with...		✓	
3.3.2.8	LPS shall provide the capability to store all CADUs which have failed CCSDS Grade-3 service processing, on a Landsat 7 contact period basis.	✓	✓	
3.3.2.9	LPS shall provide the capability to perform Bose-Chaudhuri-Hocquenghem (BCH) error detection and correction on the mission data zone contained in the VCDU (CCSDS processed data) in accordance with the Landsat 7 spacecraft data format information ...		✓	
3.3.2.9.1	LPS shall provide the capability to perform BCH error detection and correction on the data pointer zone contained in the VCDU (CCSDS processed data) in accordance with the Landsat 7 spacecraft data format information ...		✓	
3.3.2.10	LPS shall provide the capability to store all CADUs which have failed BCH error detection and correction, on a Landsat 7 contact period basis.	✓	✓	
3.3.2.11	LPS shall start a new sub-interval on detection of a change in the VCID.		✓	
3.3.2.12	LPS shall provide the capability to delete fill VCDUs.		✓	
3.3.2.13	LPS shall provide the capability to collect and store Landsat 7 return link (input) quality and accounting data...	✓	✓	
3.3.2.14	LPS shall locate ETM+ minor frames in each received VCDU ...		✓	
3.3.2.15	LPS shall perform ETM+ major frame synchronization using ETM+ minor frames...		✓	
3.3.2.16	LPS shall provide the capability to band deinterleave Format 1 ETM+ data ...		✓	

REQ #	REQUIREMENT SUMMARY	HW	SW	OPS
3.3.2.18	LPS shall provide the capability to reverse the order of data for ETM+ reverse scans.		✓	
3.3.2.19	LPS shall provide the capability to fill the following Landsat 7 data with preselected values...		✓	
3.3.2.20	LPS shall provide the capability to extract Mirror Scan Correction Data (MSCD) on an ETM+ major frame basis.		✓	
3.3.2.21	LPS shall provide the capability to extract calibration data on an ETM+ major frame basis.		✓	
3.3.2.22	LPS shall provide the capability to perform integer-pixel alignment for each ETM+ band using sensor alignment information.		✓	
3.3.2.23	LPS shall provide the capability to determine ETM+ data sub-intervals.		✓	
3.3.2.24	LPS shall provide the capability to process wideband data to level 0R.		✓	
3.3.2.25	LPS shall provide the capability to generate the following correlated Level 0R file(s) on a received sub-interval basis...		✓	
3.3.2.26	LPS shall generate Level 0R quality and accounting data, including the following information, on a sub-interval basis...		✓	
3.3.2.27	LPS shall calculate the spacecraft drift time based on information available in the PCD and append that time to the Level 0R data file.		✓	
3.3.2.28	LPS shall append the status data contained in the VCDU mission data zone, as specified in Applicable Document 3, to Level 0R files(s) on a major frame basis.		✓	
3.3.2.29	LPS shall provide the capability to identify the presence of calibration door activities using information extracted from the PCD.		✓	
3.3.3.1	LPS shall provide the capability to generate browse data for each ETM+ image sub-interval identified by LPS.		✓	
3.3.3.2	(Monochrome browse requirement deleted per RID R28)			
3.3.3.3	LPS shall provide the capability to generate multiband browse data from three predetermined bands of the ETM+ Format 1 scene data.		✓	✓
3.3.3.4	LPS shall include the following information on the browse data generated for each sub-interval...		✓	
3.3.3.5	LPS shall provide the capability to generate browse data using a predetermined reduction factor.		✓	✓
3.3.4.1	LPS shall provide the capability to synchronize on PCD bytes for assembling PCD minor frames ...		✓	
3.3.4.2	LPS shall provide the capability to fill missing PCD data.		✓	
3.3.4.3	LPS shall provide the capability to assemble PCD major frames ...		✓	
3.3.4.4	LPS shall provide the capability to generate PCD file(s) on a sub-interval basis.		✓	
3.3.4.5	LPS shall provide the capability to collect and store PCD quality and accounting data on a sub-interval basis.		✓	
3.3.4.6	LPS shall provide the capability to collect and store processed PCD quality and accounting data on a sub-interval basis.		✓	
3.3.4.7	LPS shall provide the capability to perform ETM+ scene identification in accordance with the WRS scheme...		✓	

REQ #	REQUIREMENT SUMMARY	HW	SW	OPS
3.3.4.9	LPS shall provide the capability to perform ACCA on both scene quadrant and full scene basis.		✓	
3.3.4.10	LPS shall use predefined comparison values in performing ACCA.		✓	
3.3.4.11	LPS shall generate Level 0R metadata (ancillary data) file(s) on a sub-interval basis.		✓	
3.3.4.12	LPS shall generate and include the following Level 0R metadata information in each Level 0R metadata file...		✓	
3.3.5.1	LPS shall notify LP DAAC on the availability of LPS files.		✓	
3.3.5.2	LPS shall coordinate the reporting of file transfer problems with the LP DAAC.			✓
3.3.5.3	LPS shall provide the capability to receive notification from LP DAAC on the successful receipt of transferred LPS files.		✓	
3.3.5.4	LPS shall provide the capability to store LPS data files until confirmation of successful transfer is received from the LP DAAC.	✓	✓	
3.3.5.5	LPS shall provide a manual over-ride and protected capability to delete all LPS files on a specific contact period basis.		✓	✓
3.3.5.6	LPS shall provide a manual over-ride and protected capability to retain all LPS files on-line on a specific contact period basis.		✓	✓
3.3.5.7	LPS shall provide the capability to generate LPS file(s) transfer summary, including the following information, on a daily basis		✓	
3.3.6.1	LPS shall provide the capability to generate and modify LPS set-up tables from operator inputs.		✓	✓
3.3.6.2	LPS shall provide the capability to collect and report Landsat 7 return link quality and accounting data for each wideband data input on a Landsat 7 contact period basis.		✓	
3.3.6.3	LPS shall provide the capability to collect and report Level 0R quality and accounting data for each wideband data input on a sub-interval basis.		✓	
3.3.6.4	LPS shall display quality and accounting data upon operator request.	✓	✓	✓
3.3.6.4.1	LPS shall print quality and accounting data upon operator request.	✓	✓	✓
3.3.6.5	LPS shall provide the capability to display LPS file(s) transfer summary upon operator request.	✓	✓	✓
3.3.6.5.1	LPS shall provide the capability to print LPS file(s) transfer summary upon operator request.	✓	✓	✓
3.3.6.6	The LPS shall allow the operator to select thresholds for results and errors reported by the LPS.		✓	✓
3.3.6.7	LPS shall automatically generate messages and alarms to alert the operator of LPS results and errors exceeding selected thresholds.	✓	✓	
3.3.6.8	LPS shall provide the capability to manually override the LPS automated functions.		✓	✓
3.3.6.9	LPS shall provide the capability to selectively enable and/or disable each of the following functions: a. Receive Wideband Data b. Generate Level 0R Files c. Transfer LPS Files		✓	✓
4.1.1	(requirement deleted)			
4.1.2	(requirement deleted)			

REQ #	REQUIREMENT SUMMARY	HW	SW	OPS
4.1.4	LPS shall provide the capability to receive and process the daily volume of wideband data within 16 hours of its receipt at LPS.	✓	✓	
4.1.5	LPS shall provide the capability to reprocess a maximum of 10 percent of the daily input volume of wideband data ...	✓	✓	
4.1.6	LPS shall provide the capability to process received wideband data at an average aggregate rate of 12 megabits per second (Mbps) (Includes 10% of overhead due to reprocessing).	✓	✓	
4.1.7	LPS shall provide a maximum of 8 hours of on-line storage for temporary retention of LPS files.	✓		
4.1.8	LPS shall introduce no more than one bit error in 10^9 bits.	✓		
4.1.9	LPS shall maintain data processing throughput performance for all Landsat 7 raw wideband data received with a BER of one bit error in 10^5 bits, without loss of level zero processed data and without retransmission.		✓	
4.2.1	LGS-LPS interface shall provide the capability of transferring wideband data at a maximum rate of 75 Mbps per LPS wideband data input.	✓	✓	
4.2.2	LPS-LP DAAC interface shall provide the capability to transfer the daily volume of LPS output files to LP DAAC at an average aggregate rate of 40 Mbps.		✓	
4.3.1	LPS shall provide the capability to receive wideband data for Landsat 7 contact periods of up to 14 minutes.	✓	✓	✓
4.3.2	LPS shall provide the capability to store wideband data for at least three contact periods for each LGS input until the start of a new (the fourth) contact period.	✓	✓	
4.3.3	LPS shall provide the capability to retrieve retained wideband data at rates equal to or greater than 7.5 Mbps for each LPS input.	✓	✓	
4.3.4	The LPS shall provide the capability to generate browse data with a reduction factor of 16 or better.		✓	
4.3.5	LPS shall provide the capability to identify ETM+ WRS scene within an accuracy of 15 meter.		✓	
4.3.6	LPS shall provide the capability to retain return link wideband data storage media for 60 days.	✓		✓
4.4.1	LPS shall provide an Operational Availability (A_o) of 0.96 or better for all processing functions.	✓		
4.4.2	LPS shall support a mean time to restore (MTTRes) capability of 4 hours or better.	✓		
4.4.3	Any LPS time to restore shall not exceed twice the required MTTRes in 99 percent of failure occurrences.	✓		

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